THE EAST MIDLAND GEOGRAPHER

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DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF NOTTINGHAM

No. 8. December, 1957 *Four Shillings*

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No. 8 DECEMBER 1957

TRIASSIC RELICS AND THE 1,000-FOOT SURFACE IN THE SOUTHERN PENNINES

P. E. KENT*

The highly coloured clays, white and yellow sands and gravels which fill large sink holes in the limestone plateau of Derbyshire and Staffordshire, the 'silica pits', have attracted attention over many years. In the early days they were usually held to be of Carboniferous material, particularly since fossiliferous 'Pendleside' shale was identified, but later it was generally realised that the pebbles in the gravels were too large to be from the Millstone Grit. and could only be derived from the Lower Triassic Bunter. In Staffordshire discovery of unaltered masses of cemented Bunter sandstone in the pockets led to realisation that most of the material must be Trias almost at the point of origin (Howe, 1897; Barke, Hind and Scott, 1920). But although Bemrose (1906) showed that in Derbyshire also the sand grains were rounded, and must be in part of Bunter origin, the Geological Survey (1920) regarded both sands and clays as of mixed origin, and the age of the pocket deposits as "indefinite, possibly Post-Triassic and Pre-Glacial", while Scott, as late as 1927, favoured a Carboniferous origin for the beds. Finally Fearnsides (1932) recorded that the heavy minerals in the sands of the Derbyshire pits were a normal Triassic assemblage, and drew the unavoidable conclusion that the sediments were let down into sinkholes from an original widespread Triassic cover which formerly rested directly on the limestone.

The date of the sinkhole deposits was unfortunately directly linked with that of the '1,000-foot surface' in which they are emplaced, and later authors from Swinnerton (1935) onwards have found it impossible to accept a Triassic age for this. Doubts have therefore again been cast on the dating of the pocket deposits. The note which follows shows that the sinkholes are in fact related to an older and higher surface. and that there is no need for escape from, and no logical way of avoiding the conclusion that the sediments are as old as Fearnsides suggested.

THE SINK HOLES DEPOSITS AND THEIR AGE.

The sink holes which have been exploited either as clay pits or as "silica pits" for quartz sand are known in three areas in mid-Derbyshire and in an area of the Weaver Hills of Staffordshire (Fig. 1). They occur mostly at 900-1,050 feet elevation, often in gentle depressions in the limestone plateau, and before working are usually marked by a marsh or mere—symptomatic of the impermeable substratum as well as of the continuing tendency to subside.

The three mid-Derbyshire groups are around Newhaven and Parsley Hay over about two square miles, on and near the High Peak mineral railway for about four miles in the section from Brassington to Minninglow, and in an isolated example at Alsop Moor two miles south of Newhaven overlooking Dovedale. The map includes three cases in the

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Brassington area recently mapped by E. M. Hughes (1952). The recorded Staffordshire examples are in the Weaver hills at Ribden and Salleymoor (1 mile south of Caldon) and on Milk Hill, Waterhouses (near Huddale Farm) on the northern slope of the hills. Others may well be discovered, especially in mid-Derbyshire, but identification of the series depends on adequate exposures, not usually available without excavation or boring.

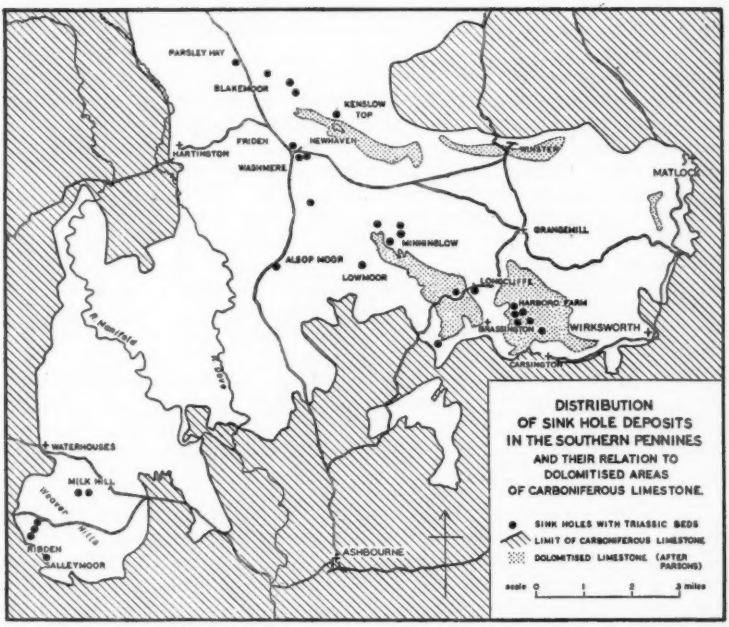

Fig. 1

The sinkholes commercially worked are commonly from 50 to 200 yards across, oval or sub-circular with vertical limestone walls. Some have been found to extend to depths of 500 feet or more without being bottomed. The deposits in them are much disturbed as a result of the progressive downward slipping as the pit developed, and it is rare to be able to make out a connected succession. In some cases (such as Alsop Moor and Kenslow Top, described below) the beds show a regular inward dip developed during even subsidence, but this is uncommon.

The shape of the sinks is in each case compatible with origin as a widened swallow hole. The linearity of some groups has led to a suggestion that they are collapsed caves of an underground river system (Edwards 1956), but there seems no support for this view from overhanging walls or bell shape. It is more probable, on the whole, that they were swallows at the junction of a former impervious cover with the limestone (see below).

Local details of the pits would be inappropriate here, and descriptions of the older sections can be found in the G.S. memoir in Refractory

Materials (1920) or in other literature cited. The red and white clays, white and yellow sands and thick pebble beds have usually been regarded as an inextricable jumble, with Carboniferous shale adding to the confusion. In 1946 however the Kenslow Top pit in the Newhaven group, worked by the Derbyshire Silica Firebrick Company, provided a remarkably clear long section through the coloured beds. The strata were arranged in a regular syncline with a small amount of disturbance, but the wedging of some members indicates a "drawing-out" process in the course of subsidence and the thicknesses are probably much smaller than those of the original deposits.

The section was as follows :—

Superficial.

6.	Brown stoney clay with much Lower Carboniferous chert	at least 10 feet
5.	Pale grey sandy clay with Carboniferous material, and scattered pebbles of quartz and limestone	0 — 2 feet

Mesozoic.

4.	Brick-red and yellow mottled sandy clays, sandier and yellower towards the base, brightest colours in upper part	45 feet
3.	Pale sand with dark carbonaceous streaks ..	1½ feet
2.	White quartz sands, coloured yellow or bright salmon-pink locally in upper part. Strings of bleached pebbles of Bunter types at intervals	5 — 30 feet
1.	Deep purple or mauve sandy clay, irregularly blotched with yellow, with pebbles and occasional bands of purple-brown and deep chocolate-brown clay, and bands of pebbles of Bunter types at 3 — 6 foot intervals ..	about 50 feet

In this sequence the white sands are of greatest economic value, being ground and fired to make silica fire bricks. The same characteristic beds are present in other pits in less certain sequence, but as individual types they have a wide geographical range. It is, moreover, notable, that the red clays are known to be at the top of the series as far away as the Weaver Hills.

In addition to these lithological types blue and grey shales and clays have been found. In the Kenslow Top pit a large mass of grey shale was removed from above the coloured beds ; this yielded badly preserved *Eumorphoceras* and hence could be dated as a relic of basal Millstone Grit—a record in line with discoveries elsewhere in the Newhaven area by Howe (1897), Jackson and Charlesworth (1920) and Scott (1927). It seems most likely that this shale mass collapsed into the sink hole at a late stage, and the common occurrence of such material in association with the coloured Triassic deposits suggests that the pits may originally have been formed as swallow holes on the contemporary edge of the impermeable later Carboniferous cover—where drainage which collected on an outcrop of shales reached the limestone and plunged underground.

The Carboniferous shale masses have an important bearing on the position of the surface on which the swallow holes first developed. The detailed stratigraphy of the central part of the Derbyshire plateau has not been worked out, but limestone hills rise 200-250 feet above the level of the pits, and unless the Upper Carboniferous shales lay on an irregular limestone surface the sink holes must have been originated at least as high as 1,250 feet A.S.L. Alternatively, if the sub-shale surface was in fact irregular—as is quite possible—the present limestone plateau would be an exhumed Carboniferous erosion plane somewhat modified by later phases of denudation. In neither case would there be a basis for linking the date of the pocket deposits with that of the '1,000-foot' surface.

The sandstones of the series may safely be accepted as Permo-Trias on the evidence of pebble-content, heavy minerals, coarse grade and rounded character of the grains. In a recent re-investigation in the Brassington area E. M. Hughes (1952) has confirmed that the heavy minerals are of Bunter and not of Millstone Grit type, has recorded "millet-seed" grains (characteristic of Permo-Trias) and has found facetted pebbles. In trying to avoid a Triassic dating for the present plateau Clayton (1953) cited cases where Bunter has been glacially transported with only very slight mixing or contamination, but it has to be recalled that the sand exposures in the silica pits are very extensive, and have been repeatedly searched for clues of date without discovery of evidence of "foreign" material. In any case there is no possibility of glacial transport of the whole bedded series, including the clays above. The cleanness and the persistence of the individual characteristic units across the southern Pennines from the Weaver Hills to Brassington and Longmoor leaves no possibility that they were "drifted" in the Pleistocene, or transported by any likely means in the Tertiary.

In the light of this the detailed correlation of the Kenslow Top succession may be considered. The red and yellow clays (4) have long been recognised as Keuper in the Staffordshire sinkholes where they are close to outcrop, and they are very likely to be of the same date here. They differ from normal Keuper mainly in the brighter colours, and in the absence of interbedded sandstones. A green facies near Brassington (like the upper Keuper Tea Green Marls) is ascribed to reduction of red marl by peaty waters from higher levels (Hughes 1952). The pale sands beneath could be either Keuper Basement Beds, which include rocks of this type near Ashbourne and Nottingham, or bleached Bunter ; the latter is more probable. The coloured sands with the characteristic Bunter pebble assemblage approximate to the Bunter Conglomerate facies, while the basal purplish marls and sandstones may also be Bunter or might in part range down into the Permian, which includes beds of this colour in places.

We do not know how far the Permian sea extended westwards into the Pennines, but it is not impossible that it transgressed at times as far as mid-Derbyshire. This possibility is suggested by the distribution of dolomitisation (Parsons 1922), which occurs in two belts on the plateau—one from Winster to Blakemoor, the other from Carsington to Roystone rocks—in striking relationship to the pocket deposits (Fig. 1). The dolomitisation is not related to mineralisation but is mainly developed in beds at plateau level ; it pre-dates part of the faulting but (in the

Matlock area at least) post-dates folding, and a Permo-Trias date for its introduction is therefore quite probable. Within this period the magnesium-rich waters of the transgressing Permian sea are the most likely source, and one could conceive of a shallow bay extending in gentle downwarp beyond Matlock. No trace of marine Permian has yet been found (and none may now exist) but the possibility that Permian littoral and terrestrial sediments were deposited in the south Pennines should be borne in mind.

The concept that the sink-hole series covers much of the Permian and Trias does not conflict with evidence of regional variation as at present known. The Permian and Triassic sub-divisions of the main outcrop thin gently from the Lincolnshire basin westwards, but none show signs of approaching failure where last seen at outcrop. The Bunter Conglomerate appears to have reached Nottinghamshire across the southern Pennines (Sherlock, 1908, p. 31 ; Swinnerton, 1948), and Bunter is well developed in valleys cut into the Millstone Grit and Coal Measures in north-west Staffordshire near Leek.

Continuing subsidence of the material as the sink-holes were deepened by solution (possibly in association with the late Tertiary uplift of the Pennines) is indicated by recovery of wood of the Tertiary tree *Dadoxylon*(1) from Harboro Farm near Brassington (Howe, 1897) and by the common survival of patches of glacial clay which have been removed from most of the plateau.

No positive evidence of beds between the Trias and the Tertiary has been found so far, but plant-bearing sands and stiff blue clays with macerated plant remains might belong to some point in this gap. Dating by spore analysis is the most promising method for investigating this problem.

Relation of the Triassic and Later Landscapes.

It has been shown above from the evidence of Upper Carboniferous shale occurrences that the pocket deposits originated on a level 250 feet or more above the present '1,000-foot' plateau, or alternatively that this is in part an exhumed Carboniferous surface. Correlation of the 1,000-foot surface with Mio-Pliocene erosion levels of southern England is hence not excluded, nor does any problem arise from the demonstrable lack of tilt of the Derbyshire plateau in contrast to the eastward slope of the Mesozoic (Linton, 1956), or from the intersection of the sub-Triassic surface south of Ashbourne with the 1,000-foot plain (Clayton, 1954).

The question then arises of the form of the sub-Triassic surface. Clayton (1954) objected to the concept of a former Triassic sheet on the grounds that the nearest Trias, that of the Ashbourne-Leek area, rests on a very irregular surface—in fact it buries a mountainous landscape. Geologically, however, there is a sharp east-west line of change between an evenly eastwards-dipping sub-Permian plain in north and mid-Nottinghamshire and the irregular surface of the Trias with varying strikes south of Nottingham. This line coincides with a fault belt which

(1) *Dadoxylon* is the somewhat uncertain index of horizon, ranging down into the Trias in Africa.

trends west-north-west past Derby and limits the Derbyshire structural block on the south. There is every reason to expect sub-Triassic irregularities to the south of this line, but also a strong expectation that they were cut into the northward slope of a hill mass which ended on this structural line where the Permian basin began. North and south of Nottingham the two types of surface remain buried for inspection, but it is reasonable to suppose that something of the same contrast also occurred on opposite sides of the faulted belt further west. The sub-Triassic relief south of Leek and Thorpe Cloud is in fact at best very slender evidence of conditions on the plateau, and typifies conditions in a hilly area known to have been progressively faulted and folded downwards relative to the rigid block during later Keuper and Jurassic times.

In contrast to this, east Nottinghamshire with the exposed coalfield and the mid-Derbyshire limestone plateau are parts of a single geological unit, and it is likely not only that the simplicity of the Mesozoic structure continued westwards into the south Pennine area, but also that the Carboniferous surface there buried by the Permian and Triassic deposits was featureless or very gently undulating. The Permian of mid-Nottinghamshire contains no breccias or terrestrial torrent deposits of the kind which occur marginal to the contemporary hill masses of the Midlands or Lake District ; the only lithological anomaly is a very local sandy development of the limestones at Mansfield. It seems most reasonable to assume that the Permian basin shelved gently westwards, and that there were minor transgressions of marine waters in the shoreline area which have left no modern trace except possibly the dolomitisation of the higher limestones of mid-Derbyshire.

Projection of the sub-Permian or sub-Triassic plain westwards without change in gradient would imply that this surface lay many hundreds of feet higher (it could clear the 2,088 ft. summit of Kinder-scout), but being on the margin of the basin of eastern England it is likely to have flattened markedly to west of outcrop, as in fact it does in the opposite direction in mid-Lincolnshire (Kent 1949). It need not have been far above present plateau level and it need not show the tilt of the Trias at outcrop to the east. The possibility that the relics of a 1,250-foot surface belong to this plain might be considered by physiographers.

Westwards the Derbyshire block ends approximately along the line of the Manifold Valley. On that line the structures change and so does the configuration ; the plateau is backed by gritstone moorlands which rise to 1,700 feet at Axe Edge. Linton and others have noticed that this belt represents the Tertiary water parting, from which the ancestral Midlands rivers flowed eastwards to the coast. It can hardly have survived in anything like its present form since the Trias, but it marked the site of the high standing margin of the Cheshire basin in Triassic times, and may well have survived as a general watershed area through much of the intervening period—perhaps being covered only by the Chalk.

History of the Southern Pennines.

From this evidence we may conceive the history of the southern Pennines to be somewhat as follows :—

1. Late Carboniferous and Early Permian—folding of the newly deposited Carboniferous rocks along the main Pennine and various minor axes, followed by erosion which bevelled the Coal Measures, Millstone Grit and the highest part of the limestone.

2. Extension of the Permian sea from the north-east as far south as Nottingham across the peneplained Coal measures, possibly with minor and impersistent transgressions westwards on to the exposed Carboniferous Limestone in mid-Derbyshire.

3. Deposition of Bunter and Keuper sandstones, on a rough irregular terrain south of a line through Nottingham and Ashbourne, but on a gently undulating plain with patches of Upper Carboniferous shales in mid-Derbyshire. Swallow holes may already have existed on the edges of the larger of these patches. Relative down-warping of the area south of the Derbyshire block beginning.

4. Development of the Mesozoic basin of north-eastern England probably accompanied by related slow uplift of "Derbyshire Dome", with development of sink-holes and progressive subsidence of existing deposits into them. Final relics of Upper Carboniferous cover slumped into swallow holes together with Triassic fill. Intermittent moderate erosion, probably interrupted by transgression of the Chalk.

5. Renewed uplift and erosion in later Tertiary times, with a long pause in the Mio-Pliocene giving rise to the '1,000-foot' surface after removal of surviving relics of the Trias and Cretaceous and general lowering of the central plateau by several hundred feet. Final deepening of sink-holes as the water table fell, with local deposition of Tertiary swamp or lacustrine beds.

6. Minor modification of plateau in glacial period, from which patches of boulder clay survive in the upper parts of the sink-hole depressions.

Acknowledgments.

Warm thanks are due to Professor K. C. Edwards for guidance to the recent geographical literature on the southern Pennines, without which this review could not have been completed, and to Professor W. D. Evans for making available the unpublished thesis of E. M. Hughes. Acknowledgment should also be made of the courtesy of the management and staff of the Derbyshire Silica Firebrick Company, of Newhaven, who have allowed successive generations of geologists free access to their workings.

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THE DISTRIBUTION OF COAL FROM THE EAST MIDLANDS DIVISION

R. C. ESTALL

The development of nuclear energy in the United Kingdom will change fundamentally the patterns of coal movement and utilisation in the country as a whole. The analysis of these changes and their repercussions on various parts of the economy (and there will be many interests affected directly and indirectly), must take place against the existing patterns of distribution and utilisation. This article discusses these patterns with special reference to the East Midlands Division. The paramount position of this division in the coal economy is well known(1), while the trading interests of the area are widely spread and in many cases of recent growth. Many features of national coal distribution can therefore be described with reference to this important field.

Statistics have been obtained of the flow of coal from the East Midlands Division to the twelve Consumer Regions of the Ministry of Power. The first year for which such figures were collected was 1948 and the last year was 1954. The analysis therefore refers mainly to 1954, but comparisons with 1948 are developed where they appear significant(2).

The circumstances of coal distribution in the United Kingdom have changed greatly since before the second world war. Post-war coal marketing is affected by the existence of the N.C.B. as a single seller, and by the persistent coal shortage which has necessitated a system of coal allocation. Unified control of distribution permits the planning of total coal flow to achieve the most logical pattern of distribution given the existing levels of production, and the kinds of coal produced, in various coalfields. But the patterns have been, and still are, greatly influenced by pre-war features. Wholesale disruption of the organisation and patterns of coal flow evolved over earlier decades would have produced hardship and dislocation for manifold interests. Therefore pre-war patterns still have validity, but are being steadily modified to be brought into line with present conditions.

Distribution of coal from the expanding East Midlands field has been developing in such a way as to offset the decline of other areas. This process is a continuing one, but the broad features of coal movement from this Division that are described below will not change to any great degree until, with the advent of ample nuclear energy, the patterns of consumption themselves change drastically.

Before analysing the movement of coal it is useful to recall the main classes of consumption to which East Midland coal is allocated. Figure 1 shows this allocation for 1948, and for 1952 to 1954, i.e. for the years over which statistics of coal movement are available. Of first importance

(1) See, for example, K. C. Edwards "East Midlands Coal Production in Relation to Britain's Fuel and Power Problem", *East Midland Geographer*, December 1956.

(2) Unless otherwise stated, statistics refer to 12 months ending October 31st. Figures for 1948 are based on a holiday-free sample. The flow of Coal is not to be equated with production. It is of the same order, but some coal may move into stocks at the pit-head for a period.

is the expansion of output of small coals consumed in *power stations*. In 1954 the total was one-third of that for the U.K. as a whole, having risen by more than five million tons since 1948. The quantities allocated to *general industrial* purposes are also large and provide a substantial proportion of the national total—almost one-quarter; while coals of the *domestic* varieties produced in the East Midlands formed 30% of the country's total allocation in 1954. In both domestic and industrial categories the quantities produced increased. but less remarkably than in power station coal.

In the production of other important grades the East Midlands holds a relatively minor position. The quantity suitable for allocation to *gas works* remained below four million tons throughout, and the North Eastern and Durham Divisions come to the fore in providing a large proportion of national requirements of these grades. The output of coal of *coking* quality is also small and met under 9% of total U.K. requirements in 1954.

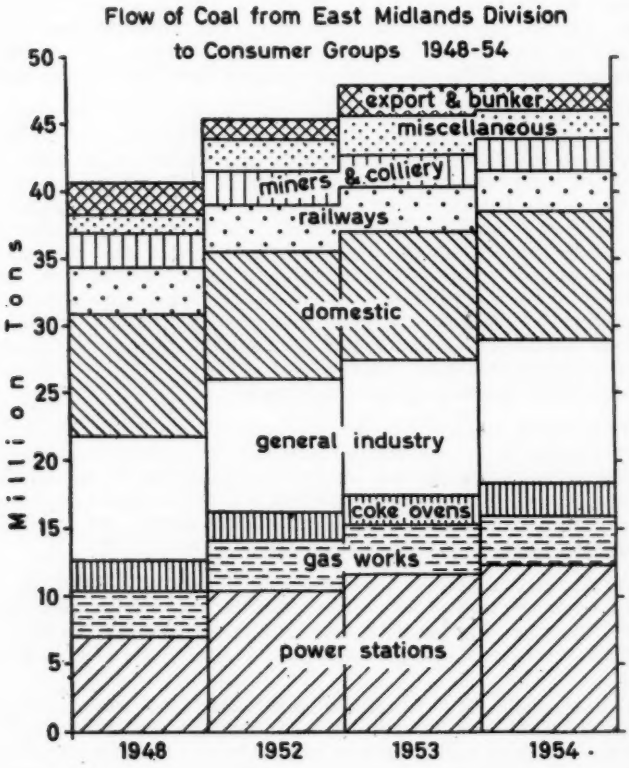


Fig. 1

Regional Distribution

The East Midlands supplies coal to ten out of the twelve consumer regions into which the country is divided. Quantities vary widely, however, and the main receiving areas are the North Midland, London, North Western, Eastern and Midland consumer regions (see Fig. 2). The importance of the East Midlands' supply to the fuel economy of the areas served also varies, and most regions receive significantquantities from other coal divisions. The East Midlands proportion of the total coal consumed in each region is shown on the map.

Coal movement can be conveniently divided into supplies to 'coal-field' regions (i.e. consumer regions with major coal-fields within their boundaries), and to 'coal-less regions'. A line drawn approximately from the Severn Estuary to the estuary of the River Nen may be used to distinguish the 'coal-field regions' to the north from the 'coal-less regions' of the south. The output of the Bristol, Somerset and Kent coal-fields is regarded as insignificant. Supplies from a Coal Board division to the consumer region within which it is located will be referred to, loosely, as 'local supplies'. Naturally, significant quantities of coal are produced close to regional boundaries and may therefore find a 'natural' market (i.e. a market most economically served by the pits in question) in the adjacent consumer region, but it is, for example, convenient to refer to the movement of coal from the East Midlands division to consumers in the North Midland C.R. (Consumer Region) as 'local supplies'.

It is logical to consider at the outset that coal produced in the coalfield regions will be moved most economically either to local consumers or to the coal-less regions of the south. Such a simplification has broad validity and 33 million out of the 48 million tons of coal (69%) moving from East Midlands collieries in 1954 was thus disposed of—over 15 million tons to consumers in the 'local' region (the North Midland), and nearly 18 million to the coal-less regions. But the fuel situation in the coalfield regions themselves is affected by both the quantities and the types of coal produced by the 'local' coalfield. Some movement of coal between coalfield regions is therefore inevitable, to make up for overall deficiencies in local supply and to provide grades of coal not produced locally. Thus even the North Midland C.R., most favourably endowed with the East Midlands coal division, brought in about five million tons of coal (26% of the region's requirements) from other producing areas in 1954. Most of this came from the adjacent North Eastern Division and some would therefore be a movement from collieries there to the nearest markets, which happen to be across the consumer region boundary. But one-half of the total was of coke-oven coal, a variety in which the East Midlands cannot provide the full requirements of its local region. In all of its remaining requirements the North Midland C.R. is fully served by the local coal division, and only negligible quantities move in from such divisions as the South West and the West Midlands.

In examining the movement of coal from the East Midlands to other coalfield regions it is noticeable that no coal is sent to the Northern and Scottish C.R.s (see map). Both these regions are largely self-sufficient in coal requirements and 'import' only relatively small quantities which are, especially for the Northern C.R., more than offset by 'exports'.

The main line of movement north of the Severn-Nen line is to the North Western C.R. Here the East Midlands supplies a growing proportion of the total coal used, 14% in 1948 and 18% in 1954, reflecting the growing inability of local coal to meet the increasing needs of the North West. This region was indeed the largest coal consumer in the country in 1954 and local coal output met under half its requirements. The North Eastern division is the largest outside source of supply, and this division together with the East Midlands provided about 41% of the total consumed in 1954. Supplies from the East Midlands help mainly to meet deficiencies in power station and general industrial requirements (see Fig. 2), while the North Eastern division is more concerned with the supply of coal for gas works and domestic use.

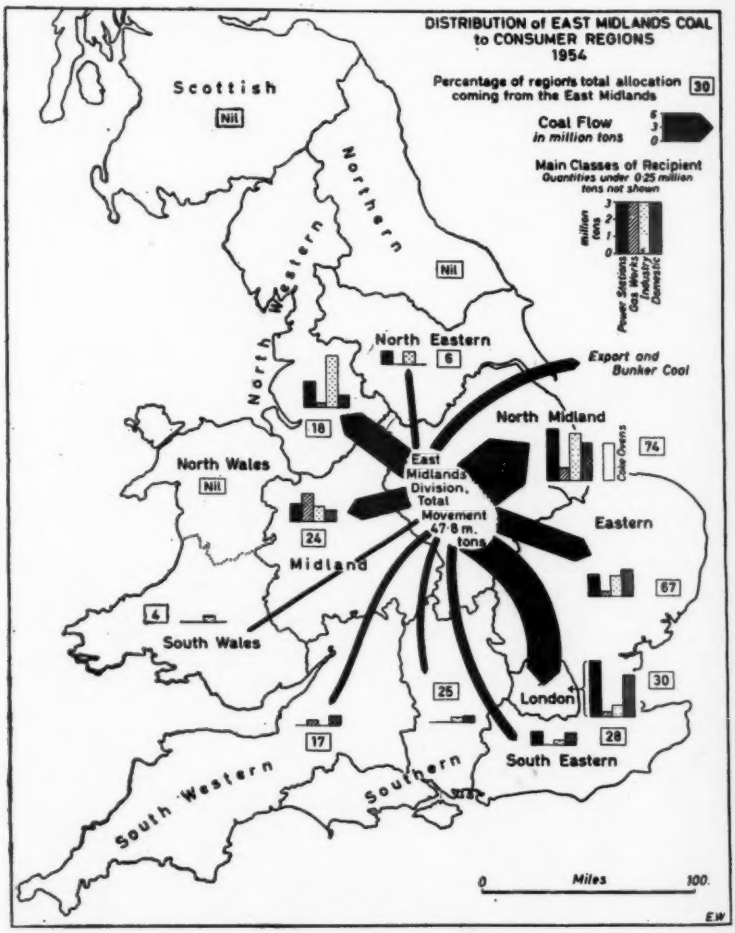


Fig. 2

The Midland C.R., though receiving a substantial quantity of coal from the East Midlands division, is not in the same position as the North Western region. The 'local' coal division (the West Midland) produces sufficient in pure quantity to meet over 90% of its requirements. Some of the relatively large quantities of coal moved in from the East Midlands is a 'natural' flow to the nearest markets from collieries on the other side of the regional boundary. In this category would fall much of the coal allocated to domestic and general industrial purposes, for the West Midlands produces more than sufficient of these coals to meet local needs and the apparent inflow is more than balanced by a corresponding movement from this division to other consumer regions—especially of domestic varieties. But the output of power station coal falls short of requirements and the output of gas coals far short. The East Midland supply helps to bridge these gaps, supplemented by the gas coals of the North Eastern division.

The remaining coalfield regions, the Welsh and the North Eastern, receive little of their coal from the East Midlands. The South Western coal division produces more than sufficient to meet Welsh requirements, but much is moved to all parts of the country, sometimes because it is cheaper and sometimes because of traditional connections. Small quantities therefore need to be brought in, mainly of general industrial types, from the East Midlands. The North Eastern coal division, for its part, is itself the major source of supply of certain grades of coal to consumer regions outside its local region. The movement of small quantities of coal from the East Midlands to the neighbouring North Eastern C.R. has therefore little significance, but it is almost entirely confined to power station and general industrial coal—grades of which the East Midlands produces much more than the North Eastern division.

The movement of coal among the coalfield regions is not easy to analyse. There exists a measure of apparent 'cross-supply" which is difficult to explain on grounds other than that of traditional contacts. Such a basis for movement, however, affects the East Midlands division with its recent large increase in output to a lesser degree than any other division in the country.

Before the flow of coal from the East Midlands to the five coal-less regions south of the Severn-Nen line is described, it is pertinent to comment on the wide diversity of sources of supply to these regions. Every coal division, only the North-Western excepted, supplies some coal to two or more of the five. Some of these are based purely on traditional contacts and are in consistent decline. For example, the total Scottish contribution to the five southern regions fell from 0·7 million tons in 1948 (when all five regions received some quantity) to 0·3 million in 1954 (when only the London and the Eastern regions were concerned).

The total consumed in the coal-less regions was about 50 million tons in 1954, and of this the East Midlands supplied 35%. This division had increased its share of the total market from slightly under 28% in 1948, and in 1954 was the largest source of supply for all except the South Western C.R. For this last region the South Western coal division is clearly the best source, though even here the quantity received from the East Midlands increased.

For the remaining four consumer regions of the south and east, the Northumberland and Durham coalfields are regarded as the traditional sources of supply. The reasons for the early monopoly of this coal trade have been fully discussed elsewhere(1), but here it is instructive to compare the position of these two long-established suppliers with that of the East Midlands in the provision of coal to the southern market at the present time. The changing patterns of production and consumption nationally have led to a marked change of emphasis in coal supply to the coal-less regions, as the following Table Shows.

SUPPLIES TO FOUR SOUTHERN CONSUMER REGIONS 1948 AND 1954
(Million Tons)

Consumer Region	*By Northern and Durham Divisions*		*By East Midlands Division*		*Total Home Produced Supplies*	
	1948	**1954**	**1948**	**1954**	**1948**	**1954**
Eastern	0·89	1·03	3·35	5·22	5·92	7·75
London	11·41	10·52	5·38	7·61	21·53	22·57
South Eastern	2·44	2·48	1·20	1·95	6·32	7·19
Southern	1·30	1·28	1·14	1·26	4·66	5·17
Total	16·04	15·31	11·07	16·04	38·43	42·68

It is seen that, while the East Midlands supplied about five million tons more in 1954 than in 1948, the joint contribution of the Northern and the Durham Divisions fell by three-quarters of a million tons. The proportion of total requirements in these four regions supplied by the 'traditional' sources fell from 42% to 36% over the period, while that from the East Midlands rose from 29% to 37%. It must be noted, however, that these changes largely derive from the movement of coal allocated to power stations. Production of such coal has not been expanding in the Northern and the Durham Divisions, while consumption of coal in power stations in the local region has increased. Meantime the East Midlands has become the largest producer of coals of this type and its output far exceeds the present requirements in the locality. Thus, while the quantity of power station coal shipped from Northumberland and Durham to the four regions under review fell by over one and a half million tons, that moved from the East Midlands to these regions increased by over three million tons. The East Midlands is therefore making good the falls in supply from other areas and providing also for the increasing requirements for this grade of coal in the south. In the supply of special grades, however, especially that for gas works, the Northern and the Durham divisions have maintained, or even improved, their position in the southern areas. The East Midland contribution of coals of this grade is almost negligible—less than one million tons for the four regions.

Though receipts of coal from the East Midlands are of importance to all the coal-less regions, the proportions originating there vary

(1) See, for example, Ll. Rodwell Jones : *The Geography of London River*

widely (see Fig. 2). The London C.R. has become the largest 'outside' market for East Midland coal and in 1954 received 30% of its total requirements from there—as compared with 25% in 1948. The old-established supremacy of Durham in the London market was challenged in 1952 and overcome in 1953 and subsequent years ; but London still relies heavily on Durham for its gas coal supplies, and entirely for its small requirements of coke oven coal. The East Midland connection is at its most important in the supply of coal for power stations and for domestic purposes.

Most heavily dependent upon East Midlands coal (apart from the 'local' consumer region) is the Eastern C.R., where 58% of total supplies originated in that division in 1948, rising to 67% in 1954. This would be expected from the relative positions of the two areas. Nevertheless the North Eastern, the Northern and the Durham divisions are called on to supply most of the gas coals and much general industrial coal. In certain parts of the Eastern region seaborne coal from the north is cheaper than railed supplies from the adjacent area. (See below for treatment of cost factors in transport.)

For the three remaining coal-less regions the total quantities involved are much smaller. Supplies from the East Midlands to the South Eastern C.R., however, rose from 19% to 28% of the total between 1948 and 1954, serving mainly power station and domestic consumers. For the Southern C.R. it is somewhat surprising to find that, while 25% of total allocation in 1954 originated in the East Midlands, very little was of coal for power stations, although power station requirements in this region increased to over a million tons, i.e. an increase of 60% over 1948. The most important generating stations in this region are near the coast and therefore receive coal more cheaply by sea. But, as is shown below, the quantity of East Midland coal moved by sea has recently grown rapidly and is mainly of the power station variety. Nevertheless the East Midlands contribution of power station coal to this region, about a quarter of a million tons in 1948, was quite insignificant in 1954, and the North Eastern, the Durham and the Northern divisions met nearly all requirements. The East Midlands supply was chiefly for domestic and general industrial purposes. The allocation to the South West C.R. is met chiefly from the South Western coal division (53% in 1954). Nearly half the flow from the East Midlands is of household varieties, while gas works are the largest single recipient group among the rest.

In general it may be said, that while traditional connections are often still maintained, the movement of home produced coal internally in the United Kingdom is increasingly originating in the East Midland division. In the sheer volume of coal available for distribution after subtracting the total requirements of the local consumer region, the East Midlands has no rival. After meeting most of the requirements of the North Midland C.R., there remained over 32 million tons for disposal elsewhere in 1954. The important North Eastern division had 22 million tons available for regions outside the North Eastern C.R. The growing importance of the East Midlands is seen to be mainly in certain grades of coal, however—those allocated to power stations, general industrial purposes and domestic consumers. In the provision of gas coals the North Eastern and Durham divisions continue to hold pride of place ;

while in the supply of coking coals the East Midlands can supply barely one-half of the relatively small requirements of its local consumer region.

Apart from increasing in importance as a supplier of coal internally in the United Kingdom, the East Midlands has also appeared as a source of export and bunker coal in recent years. In the twelve months ending October 31st, 1954, 1·75 million tons of East Midland coal went for exports and bunkers (12% of the U.K. total). Since then, however, U.K. exports have declined, as has the proportion supplied by the East Midlands. In 1956 (calendar year) only 0·8 million tons of East Midlands coal were allocated to exports and bunkers—9% of the total for the country.

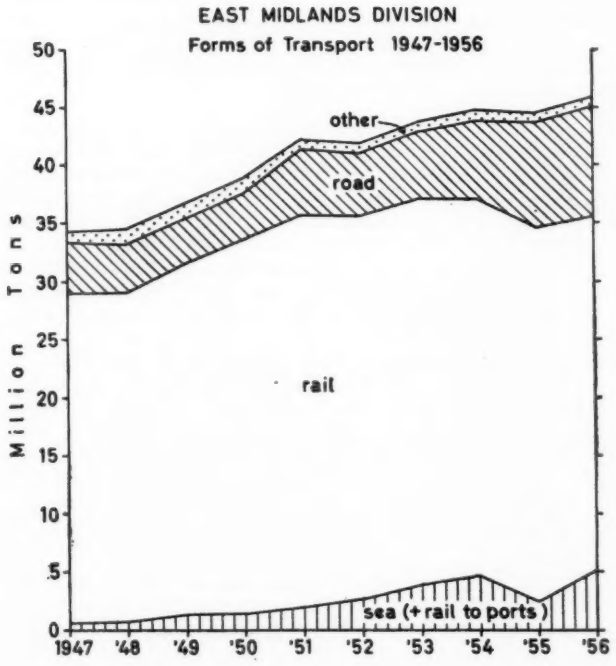


Fig. 3

Methods of Transport

Coal distributors are naturally concerned to adopt the most economical means of transport available, and they often have a choice between alternative forms or combinations of forms. The method adopted will depend on the costs incurred, on the requirements of the consumer and on his location relative to the source of supply and the transport networks. In analysing movement from a single coal division, the structure of transport costs is a main feature. (If comparisons were

to be made between various divisions, the coal price structure is a further major consideration.) For the East Midlands we can assume that the price per ton at the pithead for coal of the same grade is the same throughout(1), the cost of production at the colliery in question being irrelevant. The distributor is therefore concerned only with costs incurred directly and indirectly in moving the coal.

The graph (Fig. 3) shows the forms of transport used to convey coal from East Midlands collieries in recent (calendar) years. Three main trends are discernible. Rather surprising, in view of the distance from East Midland collieries to tide water, is the steady increase in seaborne tonnages. There is also a notable increase in movement by road, while railed quantities never rose far above the 1950 level and show a marked decrease in 1956. Figures for 1955 were seriously affected by a rail strike, which had repercussions on all forms of movement. Road tonnages rose sharply, while seaborne quantities were restricted by the inability to move coal by rail to the Humber ports. Railed quantities could recover much lost ground after the strike by the running of extra trains to clear stocks, but seaborne totals could not recover, for the turn-round of colliers could not be greatly increased.

"Other Forms" (see Fig. 3) relate mainly to movement direct to consumers from the pit-head by private rail or overhead systems, but also include transport along canals and waterways. This last is negligible both for this division (8,000 tons in 1956) and nationally.

The rapid increase in road transport calls for comment. For reasons both positive and negative in nature road quantities are increasing at the expense of rail movement. Negatively, road haulage has gained from a certain lack of competitiveness on the part of the railways. Rail charges are high, wagons are not of the most economic size and have occasionally been in short supply, and delivery has at times tended to be erratic. The Coal Board has been compelled from time to time to use extra road vehicles to get coal away from the pit-head to enable production to continue. On each such occasion the positive advantages of road haulage have been demonstrated to yet more consumers, who tend to demand more road-delivered coal in future. Thus during the 1955 railway strike more consumers had to receive coal by road, found it advantageous, and retained the method afterwards. Road movement therefore increased still further in 1956, while the volume of railed coal fell sharply. The positive advantages of road haulage are especially effective over comparatively short hauls of about 30 miles. Savings are made if that coal is delivered direct to the point of final consumption, and to an approximate time-table. This reduces the costs of storage and internal movement of coal. Further, some large consumers do not possess railway sidings and, if using railed coal, incur extra expenses for secondary transport that can be avoided by the all-road method. Such advantages may cause the incidence of road movement to increase still further, even for comparatively lengthy journeys. There are limiting factors, however. Pit-head equipment at most collieries is designed to accommodate railway wagons, not lorries, while, for a variety of reasons, coal is probably moved away from the

(1) This is true of the whole division save only Area 7, where a small coalfield adjustment charge is added.

colliery more economically by rail if the system is functioning smoothly. New capital investment in the railways should ensure this. Important for the future is that the railways can (since June 1957) quote special, undisclosed freight rates for traffic they would like to encourage. This could well improve their competitive position vis-a-vis road transport—and, indeed, sea transport too.

The movement of coal by sea is always cheaper per ton-mile than by any other form, and comparative freight rates have moved sharply in favour of the sea route since before the war. Whereas railway rates for coal rose nearly 300% between 1938 and 1957, the coasting coal rate rose by only about 60%. While a representative rail rate per ton from Yorkshire to London (January 1957) would be 39/-, to ship a ton from the Humber to London in an average collier would cost about 13/-. Seaborne coal, however, incurs additional costs in loading and discharging, while there is also the 'leadage' from the colliery to the loading wharf to be added—and this last is considerable for East Midlands coal. Further, coal moved by sea inevitably suffers more degradation in the process than railed coal, and the requirements of the consumer must be considered. The consumers' location relative to possible points of discharge is also important, for the economies of the sea voyage can be largely offset if the coal is to be moved inland. An examination of the comparative costs, and other relevant features, of moving a ton of coal of identical grade from the East Midlands to London by rail and by sea is instructive.

The rail rate from Mansfield to north London is 38/-, while the coasting rate from Immingham is 13/-. But the considerable distance between East Midland collieries and tide water involves a leadage and loading charge of about 21/-. Add discharge costs of about 4/- and the total approximates to 38/-, about equal to the rail cost. While the seaborne ton may well be in a waterside consumer's yards, however, the railed ton is still in the wagon at a north London depot and further costs have to be met for the final stages of delivery and unloading. On the other hand the railed ton will still be in fairly good shape, while the seaborne ton will contain about 30% slack by the time it is unloaded in London. This is not important for consumers of small coal (expecially power stations), but for other consumers the coal would need to be screened and only the bigger coals would be purchased. The sea/rail comparison is therefore not a simple one.

The increasing movement of East Midlands coal by sea chiefly involves power station varieties. Delivery is often straight to the consumers' yards and the degradation is not important. Here railed coal could not compete, for the final stages of delivery by rail may involve an extra 6/- per ton. Certain industrial consumers can also benefit from a riverside location and from an ability to use small coals. In the supply of larger industrial coals, and in meeting domestic requirements, sea transport from the East Midlands is not so desirable, and rail movement still predominates. For inland consumers the economics of sea *v.* rail from the East Midlands are extremely complex. Even if seaborne coals are suitable the purchaser must add the cost of moving the coal from the wharf to his site. If rail is used for this short haul a minimum charge of 6/- per ton must be met. Sometimes this cost can be reduced by using road haulage for the final stage. Nevertheless

the total costs of movement would balance very finely with that by rail. In general it may be said, therefore, that for consumers away from tidewater, transport by rail is probably the preferred form for coal from the East Midlands moving to London and the areas round about.

Conclusion

It would have been pertinent, had space permitted, to conclude with an examination of changes likely to occur in the patterns of distribution outlined here when nuclear power attains significant proportions. Coal will undoubtedly remain the foundation of the United Kingdom's power economy for some decades to come, but the type and location of consumption, and therefore the patterns of coal movement, will have to be adjusted to allow for an increasing contribution by nuclear power. A few random considerations may be stated here as a basis for further examination.

Since the nation's requirements of power station coal will be the most directly affected, it will be by the East Midlands division that most adjustments must be made. An increasing output of 'smalls' and 'fines' will find a growing market in the expansion of power station capacity along the Trent(1), but requirements of these grades in the southern regions will not increase, and will eventually begin to decline. A surplus of small coals must be in prospect which increased exports may, for a time, absorb. Subsequently other outlets must be found, but new methods of using these coals economically will doubtless have been developed.

Other coal requirements will be affected indirectly as electricity gradually encroaches on the markets for raw coal in the domestic and general industrial fields. This again will be reflected in production and distribution from the East Midlands, which provides a high proportion of these varietes. All of this will have repercussions in the transport industry, and for firms engaged in coal distribution. Coal movement generally will be for shorter distances. It is possible that demand for carbonisation coals will continue to expand but, as seen, the output from the East Midlands of coking coal and coal for gas works is not large at present. Developments in techniques of carbonisation, however, may well allow the use of East Midland coal in these ways to increase. Such random thoughts open a large field for further discussion, which cannot be attempted here.

(1) See E. M. Rawstron : "Power Production and the River Trent", *East Midland Geographer*, December 1954.

THE SPIT AT GIBRALTAR POINT, LINCOLNSHIRE

F. A. Barnes and C. A. M. King

At Gibraltar Point, where the alignment of the coast of Lincolnshire changes sharply from almost north to south to about north-east to south-west, the dunes and ridge-and-runnel sand beaches on the north side, bordering the open North Sea, give way to silt banks and mud flats within the shelter of the Wash. A morphological link between these two types of coast is provided by a spit of sand and shingle which projects south-by-west from the angle of the coast for a distance of about half a mile. Salt marsh is developing in its shelter, and dunes may eventually be built upon it (Fig. 1).

The spit is important to the naturalist because parts of its crest are normally submerged only by infrequent very high tides, and the distal end is a favourite resting place, secure from predators, for seals and sea birds when the banks further seaward are awash. For some years before 1955 it was used as a breeding site by a colony of little terns and by ringed plovers : arctic terns and oyster catchers have also nested upon it. But the spit is worthy of study not only on account of its intrinsic geomorphological interest as a land form developed in a position which is marginal in respect of particular coastal processes, and because of its usefulness to the naturalist, but also because its fate is ultimately linked with the morphological and ecological development of the whole of the southern part of the Gibraltar Point nature reserve.

The Historical Context.

Early maps show that despite the predominantly southward longshore drift of beach material on the open coast, which is always tending to produce a southward projecting spit prolonging the line of the active upper beach, the coast near Gibraltar Point has built out eastwards rather than southwards over the past two centuries. In this process several spits have grown and decayed. The present spit is a young feature with its crest near the low water mark of a century and a half ago.

Armstrong's map of Lincolnshire (1779) shows a long spit, probably carrying dunes, projecting south from the site of the old inn at Gibraltar, continuing the line of the present western dune range which was frontal at that time, and diverting the Steeping River south-westwards for about one mile. This spit had developed under protection from an offshore sandbank (Fig. 2). The First Edition O.S. one-inch map of 1824 (Fig. 2) indicates no major change over the preceding forty-five years although it represents the spit as four separate islands strung along the line of the feature shown by Armstrong.

During the first half of the nineteenth century the offshore bank appear to have moved in such a way that the area of the Point became increasingly exposed to waves approaching from south-east. However, the coast to the north remained protected by the Inner and Outer Knock, and the eastern dune range, with the salt marsh which developed

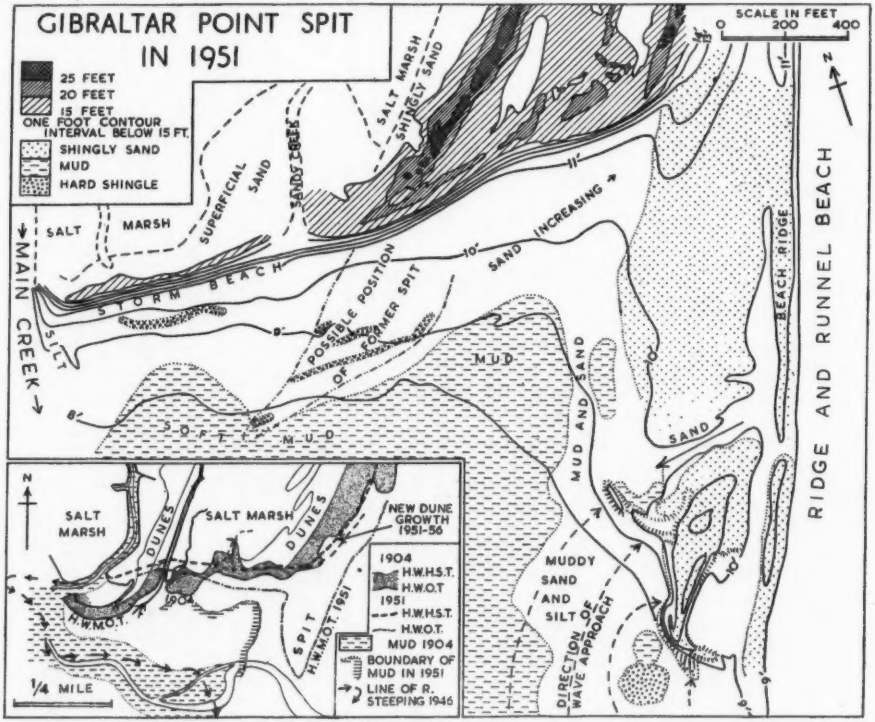

GIBRALTAR POINT SPIT
IN 1951
25 FEET
20 FEET
15 FEET
ONE FOOT CONTOUR INTERVAL BELOW 15 FT.
SHINGLY SAND
MUD
HARD SHINGLE
SCALE IN FEET
0 200 400
N
SALT MARSH
SHINGLY SAND
SUPERFICIAL SAND
SANDY SOIL
SALT MARSH
MAIN CREEK
SILT
STORM BEACH
POSSIBLE POSITION OF FORMER SPIT
SAND INCREASING
MUD
SOFT MUD
MUD AND SAND
SAND
BEACH RIDGE
RIDGE AND RUNNEL BEACH
SALT MARSH
DUNES
SALT MARSH
DUNES
NEW DUNE GROWTH 1951-56
1904
H.W.H.S.T.
H.W.O.T.
1951
H.W.H.S.T.
H.W.O.T.
MUD 1904
BOUNDARY OF MUD IN 1951
LINE OF R. STEEPING 1946
H.W.M.O.T. 1951
H.W.M.O.T.
SPIT
1/4 MILE
MUDDY SAND AND SILT
DIRECTION OF WAVE APPROACH

Fig. 1

contemporaneously in its shelter, were established by 1870. The drainage channels north of the Point in 1824 suggest that salt marsh may have been developing already in the shelter of sand ridges, and above an earlier sandy beach which has been revealed by borings in the present mature salt marsh. The curving shingle bands in the main salting revealed by vegetation imply a complex process of development which has not yet been worked out in detail. Such features are more closely comparable with the shore bars on which new dunes are growing at present between Seacroft and the Point than with the present spit.

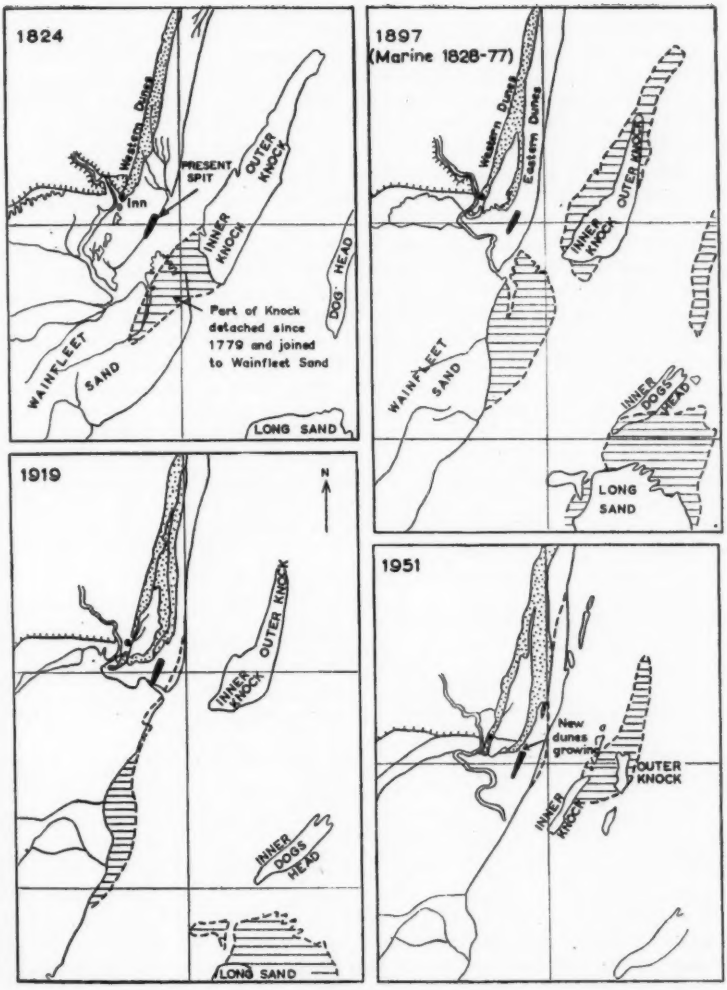
The six-inch O.S. map of 1904 (see Fig. 1, inset) shows the eastern dune range well established, although by this time the southward movement of the Outer Knock had exposed the coast south of Skegness to erosion. Exposure to the south-east increased further with the southward retreat of Wainfleet Sand (Fig. 2) and a slight northward decay of Inner Knock. Only the basal portion of the 1779 spit, markedly hooked, remained. A subsequent northward recession of the coast at the southern end of the western dunes and western part of the main salting (Fig. 1, inset) has been linked with the construction of the storm beach across the end of the marsh, and a reversal of some of the marsh drainage(1). The storm beach is underlain by marsh clay and silt, indicating that this bank of shingle and sand has been driven north across salt marsh and the marsh deposits in front of it eroded away. Borings behind the storm beach show that sand and shingle have been spread periodically over that area. A comparison of published maps suggests that this process was already well-advanced at the turn of the century. The sand and shingle may have been derived partly from a second spit which continued south-westwards the line of the major ridge of the eastern dunes, since such a feature must have existed at some stage to provide shelter that allowed the accumulation of the marsh deposits over which the storm beach ridge has been driven. Mapping in the present New Marsh has revealed hard pebbly surfaces (Fig. 1) which are suitably disposed to represent parts of the foundation of such a destroyed spit.

The present frontal dunes near the Point have been built upon an independent shingle bank separated from the inner lines of the eastern dune system by a former salt-marsh strip now covered with sand. These dunes were not present when the six-inch O.S. map of 1904 was surveyed, and their vegetation suggests that they may be not more than about twenty-five years old. Their establishment as permanent features indicates that the beach in front of them has been raised by marine deposition, and this process must have been associated with the initiation of the present spit to the south, which can hardly be older than the dune line.

The Development of the Spit since 1946

Whatever the date of origin and initial form of the spit its development over the past decade can be traced in some detail. Aerial photographs of September 1946 show a well-marked beach ridge extending

(1) F. A. Barnes and C. A .M. King, "A Preliminary Survey at Gibraltar Point, Lincolnshire", *Bird Observatory and Field Research Station, Gibraltar Point, Lincs., Report for* 1951 (1952), pp. 41-59.



COASTAL AND INSHORE CHANGES NEAR GIBRALTAR POINT

≡ AREA LOWERED TO BELOW LOW WATER ORDINARY TIDES SINCE PREVIOUS SURVEY.

0 1 2 3 4 5 MILES

Fig. 2

from far to the north past the Point in front of the present spit. Landward of it, south of the Point, was a spatulate sand bank with a narrow ridge at its southern end, the fore-runner of the spit. Its entire surface was wet when photographed, and stereoscopic examination gives no reason to suppose that it was higher than the active beach ridge in front of it. The broad bank of which this early spit was the most northerly and most prominent part continued south-south-westwards to divert the Steeping outfall much farther south than was indicated in 1904.

In 1950 the spit was still broad and relatively flat in the north, but rose in the south to a high narrow ridge which was being colonised by vegetation. In August 1950 300 plants of Agropyron junceum (sea couch grass) and 57 of Salsola kali (prickly saltwort) were counted on the spit, and a few seedlings of Suaeda maritima (herbaceous seablite) were observed in the low area behind it(1). No heights were measured, but the vegetation indicates a crest height above 13 feet O.D.(2). By September no living plants could be found, for an exceptionally high tide, probably above 14 feet O.D., had washed over the spit, which is said to have lost about one foot in height. However, in May 1951 small low dunes were growing again, and by July vegetation was re-established on them. In 1951 Salsola kali was dominant on the sandy patches, and there were only a few seedlings of Agropyron junceum and two of Cakile maritima (sea rocket), proportions which suggest that the spit was lower than in the previous summer. Eye observation suggested it to be also wider and flatter. On this and subsequent dates for which data are given in Table 1 accurate surveys were made.*

TABLE 1

Date	Height of highest point on spit in feet	Area above specified contour south of the line AB in Fig. 3 in thousands of square feet.		
		10 ft.	11 ft.	12 ft.
Summer 1950	over 13.0	—	—	—
May 1951	12.80	128.5	44.3	6.7
August 1951	12.95	—	46.3	9.9
April 1952	11.9	187.9	45.8	0
August 1952	11.7	207.2	43.8	0
April 1953	12.5	202.8	78.5	8.3
Novem. 1953	12.0	—	—	—
April 1954	11.9	—	60.7	0
June 1955	11.9	329.7	100.3	0
April 1957	12.0 +	289.8	153.6	7.1

Heights are above O.D. Liverpool.

(1) C. G. C. Chesters, A preliminary account of the vegetation of the foreshore from Seacroft to Gibraltar Point, *Bird Observatory . . . . Report for* 1950 (1951), pp. 48-57.

(2) In the mature salt marsh the critical height for Agropyron junceum is about 11.7 feet O.D., above which immersion by sea water is infrequent. On the open coast wave swash raises the height to about 13 feet. Salsola kali, somewhat more tolerant, will thrive down to 6 inches to 1 foot lower.

* Students taking Geomorphology in the Honours School of Geography at the University of Nottingham gave assistance in some of these surveys.

In 1950 the distal end of the spit had the form of a simple, straight steep-sided bank. By May 1951 there were signs of recurving on the inner side across the line of the shallow depression which had cut off the distal end in the previous autumn, and by July 1951 recurving was also apparent at the southern end of the spit proper (Fig. 1). The position and shape of the inner recurve are explained by the way in which waves were refracted round the end of the spit, and when a sufficient depth of water had been gained on the rising tide over the mud of the New Marsh were able to build a beach of the sand washed across the transverse depression (Fig. 1). The development of the landward and seaward terminal recurves was related to the formation of a beach ridge up to a height of over 10 feet O.D. in front of the spit. This ridge was low in May, the beach having been flattened earlier by storm waves, but it developed rapidly and moved in between May and July. Since the spit was protected from frontal wave attack it could be worked only by waves refracted round the end of the beach ridge and approaching from between south and west. This also explains the steepness of the southern end slope of the spit.

The shallow transverse depression divided the wide, flat northern area from the complex distal end. The soft upper surface of both parts of the spit, little worked by waves, were subject to gain and loss of sand by blowing, and provided a source from which sand was blown periodically on to the new marsh behind, to drive back the colonising Salicornia (samphire) and Spartina townsendii (rice grass).

By late August 1951 only a few moribund specimens of Salsola kali were left upon the spit due to a combination of immersion and sand loss, although the crest of the spit was a little higher than in May, and the area above 12 feet O.D. slightly bigger. Between September 1951 and February 1952 the spit crest narrowed again, gained height, and moved westwards by about 20 feet. In late March 1952 a series of high tides accompanying sustained strong winds from the east destroyed the ridges on the less protected upper beach and caused significant changes in the form of the spit, which became lower, broader and more spreading. A survey in April 1952 showed that the spit crest had been lowered but the area above 10 feet O.D. had been much extended in the northern part of the distal end. Material had been removed from the seaward side of the spit, while deposition took place on the landward side, where the bounding beach remained steep.

In August 1952 both the 10 feet and 11 feet contours had receded northwards slightly, but a new high beach ridge, which re-formed after having been flattened in March, had moved in and was in process of welding on to the seaward face of the spit. For this reason the area above 10 feet O.D. given in Table 1 includes part of the beach ridge, and is much too large to be properly characteristic of the stage of development of the spit.

The survey of April 1953 is especially interesting because it shows that the spit gained considerably from the great storm of January 31—February 1, 1953. A new crest line above 12 feet O.D., with a maximum height of 12·5 feet O.D. was found to be 40 to 50 feet west of the crest line of two years earlier. The 11 feet contour had extended westwards and southwards, and the area it enclosed had almost doubled. Although the area above 10 feet appears from Table 1 to have decreased, this is

partly due to the misleading figure for August 1952. In fact the 10 feet contour was driven west by the combing of material from the face of the spit by storm waves, but in April 1953 it reached more than 150 feet farther south than in August 1952. The spit had become much bigger than even these figures suggest, for its extended distal end was a broad expanse of shingle and sand declining very gradually in height southwards to 8 feet and below. This had been built south of the earlier steep end face in an area which had been no higher than 7 feet O.D., and this implies a very large accretion. The zone of loss in the east was much more than balanced by gains elsewhere.

During the winter of 1953-4 the spit lost height and volume, but the survey of June 1955 showed a renewed building out at 11 feet, especially in the south-east and in the west, a south-eastward extension of the 10 feet contour, and a gain along the seaward face by the welding of another beach ridge on to it.

The most recent survey of the distal end of the spit in late April 1957 shows that the increase in its volume has continued. The spit is now narrower, longer and higher than in 1955. The 11 feet contour has extended 300 feet southwards ; and although the total area above 10 feet is slightly smaller, the area above 11 feet has increased by about 50%, while the highest part of the distal end has moved about 400 feet south taking heights of over 12 feet into an area which was 2 feet lower in 1955. The narrowing, steepening and reduction in area above 10 feet is mainly due to the absence of such a beach ridge immediately in front of the spit as was present in 1955. This allows waves to act directly on the shingly sand of the front face of the spit to form a steep swash slope. The inner recurve has shifted north-east, its steep face on that side sharply bounding extensive mud, indicating that sand has been driven over it by waves coming round the spit from the south-west. This may be related to a gain in height of the transverse depression (which is nearly everywhere above 11 feet), which prevents sand being washed through the depression except during the highest tides.

No vegetation has been seen growing on the spit since the summer of 1951. The maximum height in June 1955 and April 1957 was a little too low for the establishment of Salsola kali or of Cakile maritima, which has become very prominent near the Point since the 1953 storm. Indeed in the summer of 1955 as in March 1957 very high tides were observed to be entirely submerging the spit, and the little tern colony had transferred its breeding site elsewhere after several precarious seasons. It is appropriate therefore to consider, in view of its ecological retrogression, whether the spit has lost or gained ground as a geomorphological feature since detailed surveys began in 1951.

Table 1 clearly shows that while the spit crest was lower in April 1957 than in 1951 by about one foot, the distal end was more substantial. The area above mean high spring tide level (10·9 feet O.D.) had apparently more than doubled by 1955 and more than trebled by 1957. If one-foot contours for July 1951 and June 1955 are superimposed it is found that the position of the spit as a unit changed little. The pattern of height gain and loss over the spit area is shown in Fig. 3. This shows clearly that accretion was many times greater than loss in volume. The erosion on the seaward face was insignificant because gains and losses there are cyclical : otherwise there was loss only from the crest at the distal end. This loss was small in volume but crucial in respect of vegetation growth

and nesting on the spit. The biggest gains were in the south and west, particularly in the zone immediately behind and south of the 1951 feature.

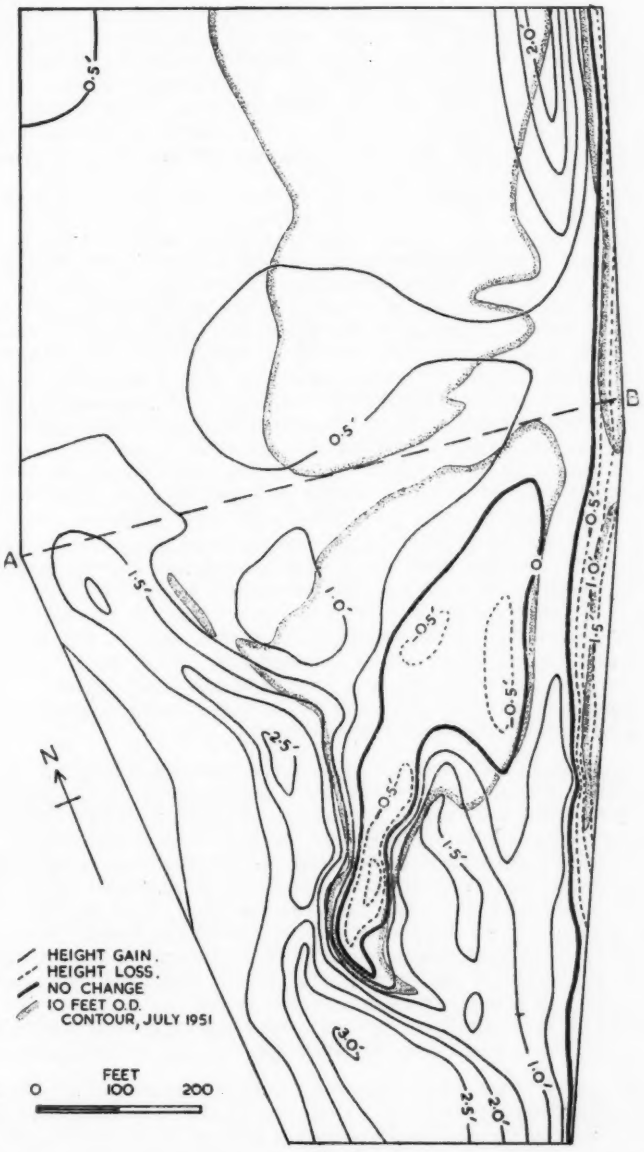


Fig. 3

Gibraltar Point Spit; height, gain and loss, July 1951 to June 1955.

The Place of the Recorded Changes in the Probable Cycle of Spit Development

Two important questions remain to be considered; namely, how the great increase in the volume of the spit fits into the probable life history of the feature, and if and when the spit is likely to regain the additional height which would again allow vegetation to colonise it and initiate substantial dune development. At present the spit crest is oscillating about a level which is a little too low. These questions can be answered only through a consideration of the major processes which are involved in the development of the spit and the adjacent areas.

The spit is composed of layers of shingly sand and sandy shingle, with shingle more abundant in the layers on the seaward than on the landward side because sand is more easily washed across the crest at high tide. It may be regarded as an extension of the upper beach, added to from time to time in a similar way by beach ridges welding on to its front face, but liable to suffer equal losses in the intervening periods, so that these are not contributions towards relative permanence. However, wave work on the inner side of the spit is constructive on balance, and material washed over the crest is sheltered from destructive combing, so that the spit increases in width by additions on its landward side. On the sea side constructive waves move material up to high spring tide level, but storm action is needed to throw coarse material up above the level of disturbance by normal wave action. Accumulation of wind-blown sand is essentially a secondary process with no real influence on the course of development until the shingly surface has been raised in this way. The more substantial the spit the more likely is it to achieve a 'permanent' increase in height, for the feature must be wide enough to undergo destruction on its seaward face without losing its identity while material is being thrown up on to its crest by storm waves. In this respect, therefore, the deposition on the west side of the spit is a contribution towards its fuller development. The most auspicious circumstances for further growth in height would be an episode of storm when shingle is relatively abundant on the upper beach, followed by the growth of a protective beach ridge in front.

The shingle and sand composing the spit are nearly all moved southwards into its vicinity by wave action along beach ridges, a movement which may be interpreted as a bodily southward migration of ridges which diverge slightly from the line of the coast. Where the rate of inshore movement of material exceeds the rate of alongshore drift a proportion of the sand and shingle at the northern end of each ridge is welded on to the upper beach as the ridge passes, and the coast builds outwards. The differential rate of normal and lateral movement depends on the direction of dominant wave approach, and this complex value in turn depends partly on the height and position of the offshore sandbanks, and is likely to change slowly as the banks change in size and position. Generally these banks appear to migrate slowly southwards (Fig. 2) so that zones of accretion may also migrate slowly in response.

The great outgrowth of the coast between Skegness and Gibraltar Point during the past twenty-five years has altered the beach alignments there. The area of most rapid accretion appears to be shifting slowly southwards, and the rapid growth of new foredunes on the east side of the Point during the past four years suggests that the beach there is

already beginning to undergo a new phase of accretion, which should make the seaward face of the spit less vulnerable to erosion. If a storm bank is raised on the present spit before this phase is too far advanced dunes may successfully grow on the spit.

Former spits in this vicinity appear to have undergone a cycle of development in which accumulation, widening and lengthening at an irregular rate was followed by the development of a hook form and shortening, and this in turn by a final phase of gradual decay as shelter on the east side diverted incoming material from the spit. This cycle is related to the way in which the coast has built out eastwards with an east to west shore at the southern end of the area of accretion. There is no reason to suppose that the present spit is not undergoing a similar cycle of development.

In the case of the present spit the period 1946 to 1955 represents a part of the first phase of development, which will probably continue for a period of years as the beach slowly builds out to the north, and possibly until a new line of dunes becomes established there. Ultimately a new spit may be expected to prolong this new line, and the present spit will be worked predominantly by waves refracted round the new feature. Its distal end will have swung westwards already to form a hook, and this will be driven north-westwards across the present new marsh as it decays. Eventually whether the spit develops dunes or not it is destined to decay as the next spit progresses through a similar cycle, but the timing will depend upon the development and movement of the protecting banks offshore, and of these virtually nothing is known.

A STUDY OF WATER SUPPLY IN DERBYSHIRE

ALAN G. LOCKYER

INTRODUCTION

With the expansion of cities and towns in the 19th century it became increasingly important to secure adequate resources of pure and wholesome water. Upland areas, with their relatively heavy rainfall, were seen to be most suitable, and although other factors, such as geology and the suitability of sites for reservoirs, needed to be taken into consideration, the development of these suitable areas soon began. It is one of these, the North Derbyshire area comprising the upper reaches and tributaries of the River Derwent which will be examined here in its relationship to the pattern of water supplies in Derbyshire and the surrounding areas.

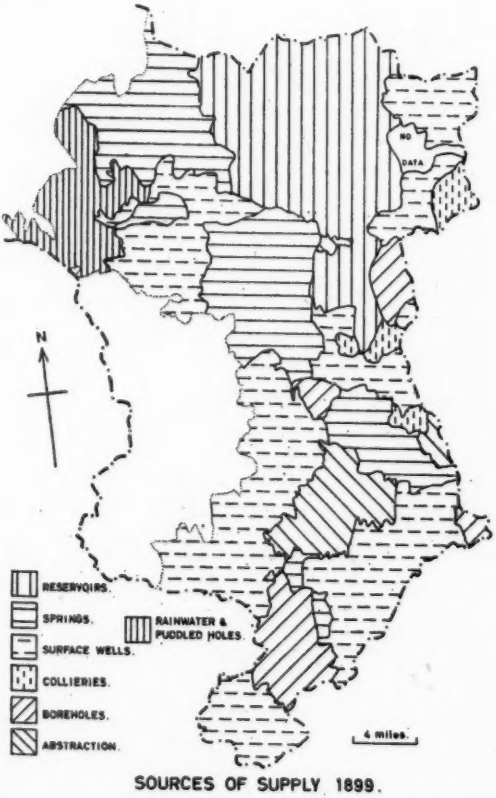


Fig. 1

Derbyshire—Sources of Supply 1899. (Data obtained from Barnes and Storey, *Report on Water Supplies in Derbyshire*, 1899).

Past Supplies

In the late 19th century the upper reaches of the Derwent and its tributaries, the Alport, Ashop and Noe, were only of local importance to the relatively scattered population of the area. They were in fact little used for water supply although the Derwent and the Noe were still quite important as sources of power and soft water for textile industries.

The sources of supply in 1899 for all except the western and north-western areas of the county are shown in Fig. 1. Considerable diversification of source is apparent but as the map does not show the actual extent of piped supplies the picture is only a partial one. At this time piped water was not universal even in urban areas and few rural areas possessed any unified schemes at all.

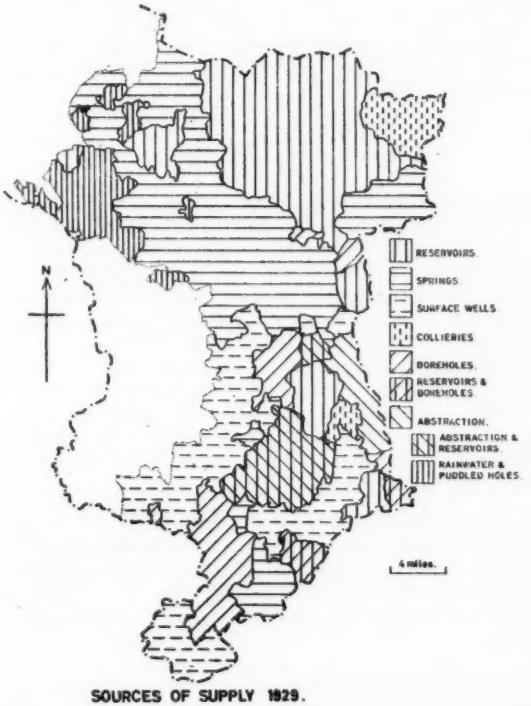


Fig. 2

Derbyshire—Sources of Supply, 1929. (Data obtained from Stephens, *Wells and Springs of Derbyshire*, 1929).

In this same year (1899) the Derwent Valley Water Board was created by Act of Parliament following an amalgamation of conflicting bills presented separately by Derby, Leicester and Sheffield for the development of the resources of this highly favourable area of northern

Derbyshire(1). The Board was formed to develop those resources as bulk supplies for the three towns named above, for Nottingham and for various Derbyshire County Water Authorities, except for those situated within the Rother Valley which were specifically excluded from the scheme. This choice of a water board supplying only in bulk was to prevent any one authority controlling all the water resources from this favourable area. The supply which it provides is shared in statutory proportions between the constituent authorities, with provisions for other adjustments between the authorities themselves and their bulk supply areas.

By 1929 the pattern of sources of supply was even more broken than in 1899 (Fig. 2.) Piped supplies were more widespread but by and large they were using restricted local sources and hence the multitude of small schemes. At this time however there were still quite extensive areas without piped water, notably in Bakewell and Repton R.Ds. The map for 1929 does show the influence of D.V.W.B. upon the water supply pattern, a number of the older and more local sources being increasingly augmented by a supply from D.V.W.B. A notable example in this respect was Long Eaton U.D.C.

Present Supplies

The present day pattern shows a much more uniform type of source as poorer sources have been replaced by better ones. In Figure 3, as in the other maps showing sources of supply, no indication is given of the relative importance of the sources where more than one is shown. This is due to the scanty nature of information on this point. It is also important to note that in the case of authorities receiving bulk supplies (Fig. 5), the source of that supply is given in addition to those developed by the undertakings concerned. Long Eaton and Alfreton U.Ds. are cases in point, their water coming from the reservoirs of D.V.W.B. and also from their own boreholes. Ripley U.D. also demonstrates this in that it has now no sources of its own, relying entirely upon bulk supplies from differing sources—the reservoirs of D.V.W.B. and river abstraction via Ilkeston and Heanor Water Board.

D.V.W.B. has played a large part in the making of this more uniform pattern both by its bulk supplies to authorities within Derbyshire and on a wider basis by its supplies through the constituent members to other water authorities in the North Midlands (Fig. 5). Thus, water from North Derbyshire has replaced or augmented local supplies over a very extensive area.

(1) The main works of the Board are Howden Dam (completed 1912), Derwent Dam (completed 1916) and Ladybower Dam (completed 1946) in the main Derwent valley, with filters at Yorkshire Bridge and Bamford. Water is also diverted into the dams from the Rivers Ashop, Alport and Noe by means of catchwaters and aqueducts. The total catchment area for these works is 38,490 acres.

For supplying authorities south of Bamford the D.V.W.B. maintains an aqueduct, 54 miles long, running to the county boundary with Leicestershire at Sawley and with Nottinghamshire at Langley Mill. Ambergate reservoir (capacity 28 million gallons) acts as service reservoir for this aqueduct. The supply for Sheffield Corporation is passed unfiltered through the Rivelin Tunnel. The water supplied is all obtained from moorland catchment areas and is therefore 'soft', but future supplies will be obtained from limestone or hard water areas.

D.V.W.B. now supplies to the constituent authorities some 42·8 million gallons per day which is divided according both to the demands of the county authorities and to the statutory proportions mentioned earlier. At present the county authorities have first call upon up to 6·5 m.g.d. (although they take only 3·47 m.g.d. at present), the remaining water being divided amongst the four towns as follows: Derby 25%, Leicester 35·72%, Nottingham 14·28% and Sheffield 25%.

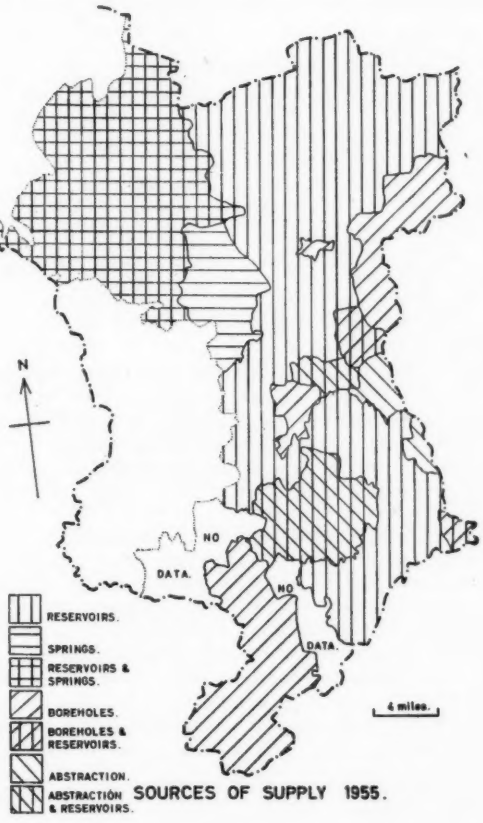


Fig. 3

Derbyshire—Sources of Supply 1955. (Data obtained from *The Water Engineers Handbook*, 1955).

The 1899 act allows for the redistribution of water amongst the constituent authorities themselves and also allows them to sell "such water as they may not now require" to other authorities within their own county or the "Sheffield Area". The first clause means that adjustments have to be made in the proportion received by the town. Derby has made extensive use of this clause and since 1928 has not taken its full

entitlement from the Board although reserving the right to receive 25% each time the supply has been increased. After adjustments have been made for sales and purchases under the various agreements, the proportions become : Derby 19·30%, Leicester 36·40%, Nottingham 14·50% and Sheffield 29·70%. With the present reliable yield of 42·8 m.g.d. plus 0·55 m.g.d. purchased compensation water, the Board's resources are 43·35 m.g.d. After the supply for county authorities has been met this leaves 39·88 m.g.d. to be divided in the above proportions. The totals available for the towns and the county authorities are set out in Table 1.

TABLE 1

SUPPLIES AVAILABLE BY STATUTORY PROPORTIONS AND NOTICES

Authority	*gallons per day*	*Authority*	*gallons per day*
Derby C.B.	7,698,600	Bakewell U.D.C.	75,000
Leicester C.B.	14,517,200	Belper R.D.C.	700,000
Nottingham C.B.	5,803,700	Chapel-en-le-Frith R.D.C. ..	42,000
Sheffield C.B.	11,860,500	Long Eaton U.D.C.	800,000
Alfreton U.D.C.	600,000	Ripley U.D.C.	320,000
Bakewell R.D.C.	131,500	Shardlow R.D.C.	804,750

The clause relating to bulk supplies enables the town to enter into agreements which aid other smaller authorities with their supply problem (Fig.5)—Sheffield alone has bulk supply commitments amounting to more than 8 m.g.d. This system of local bulk supplies within an overall bulk supply system would suggest the possibility of closer integration and some reorganisation.

In order to aid the constituent authorities, and more especially the towns, with their supply problems a special order was obtained in 1953 which enables the Board to purchase compensation water at the rate of 2 m.g.d. when the flow of the river Derwent at Derby exceeds 200,000,000 gallons per 24 hours. This water is then distributed at an even rate of 0·55 m.g.d. over the whole year. Additional water to aid undertakings with their problems is also made available when the reservoirs are over 90% full. Although restricted to some extent by the size of filtering works and aqueducts, this additional water has been of great assistance to the large authorities whose demand is increasing greatly each year. In fact the Board has really become dependent upon additional water in order to keep up with the demands of the constituent authorities. The actual totals made available to the towns and the total for the county authorities are laid out in Table 2. This total figure of 44·44 m.g.d. compared with the figure of 43·35 m.g.d. for the reliable yield plus purchased compensation water, serves to show this dependence upon additional water. The total of 3·29 m.g.d. for county authorities differs from that of 3·47 m.g.d. given above in that it is the actual quantity used, the latter figure being the amount governed by notices to the Board by individual authorities. Notice has to be given if the authorities wish to have their supply increased and thus there tends to be a time lag between notice of such increase and the taking of the full amount.

TABLE 2

TOTAL QUANTITY OF WATER SUPPIED DURING 1955

	million gallons per day
Derby C.B.	7·72
Leicester C.B.	15·00
Nottingham C.B.	6·13
Sheffield C.B.	12·43
TOTAL to four towns	41·28
Derby County Authorities	3·29
TOTAL supply ..	44·57
minus Aqueduct losses	0·13
	44·44

All types of local authority are in receipt of a direct bulk supply from the D.V.W.B. (Table 1 and Fig. 5) : these in turn supply in detail, that is to the consumer, or as in the case of the large urban authorities both in bulk and in detail. These secondary bulk supplies mean that the authorities outside Derbyshire must be considered especially in relation to any future plans for the area. With the exception of Sheffield's supply to Rotherham which is one-sixth of its supply from D.V.W.B. and is under statutory agreement, all these bulk supplies are the concern of the authorities themselves. Derby's supply to Chesterfield, Bolsover and Clowne Water Board is interesting in that the water is drawn by the Water Board from the D.V.W.B. main at Chatsworth, the water so drawn being credited to Derby, as authorities within the Rother Valley are not allowed access to D.V.W.B. water under the act of 1899. This agreement was negotiated in 1946 and is valid for 20 years, Chesterfield drawing some 777,000 gallons per day.

TABLE 3

DEGREE OF DEPENDENCE UPON D.V.W.B. SUPPLIES

Authority	%	*Authority*	%
Leicester C.B.	82·0	Shardlow R.D.C.	75·4
Derby C.B.	71·4	Alfreton U.D.C.	64·6
Sheffield C.B.	34·76	Ripley U.D.C.	49·2
Nottingham C.B.	28·5	Bakewell U.D.C.	46·9
Belper R.D.C.	82·8	Chapel-en-le-Frith R.D.C. ..	7·61
Long Eaton U.D.C.	81·1	Figures for Bakewell R.D.C. not available	—

Within this range of authorities there is a varying degree of dependence upon water from D.V.W.B. This depends largely upon the efficiency of the undertaking's own sources and their policy with regard to future supplies. However some general trends do emerge even from percentage figures as given in Table 3. The main contrast is between the large cities and the small towns. Leicester and Sheffield especially need all the water they can get and are using their own resources to the full. Other authorities, notably Alfreton U.D., are relying more and more

upon D.V.W.B. sources and are using their own sources only as a supplementary supply or reserve. There has been a tendency on the part of the county authorities to increase their notices to the Board rather than to develop their own resources in order to meet increased consumer demand. This is not necessarily the fault of the authorities themselves as the case of Alfreton U.D. demonstrates. In 1949 a proposal to sink a new borehole was subject to public enquiry and the Ministry of Health, then responsible under the 1945 Water Act, recommended increased supply from D.V.W.B. Thus by 1954 the Urban District's demand upon D.V.W.B. had more than doubled and this was partially reflected in the difficulties encountered by the boroughs. Again, in Rural Districts the gradual extension of unified systems of supply over their areas and the discontinuation of supply from numerous small sources, has correspondingly increased both the amount taken by such undertakings as Bakewell R.D.C. and Belper R.D.C. and also their dependence upon water from D.V.W.B.

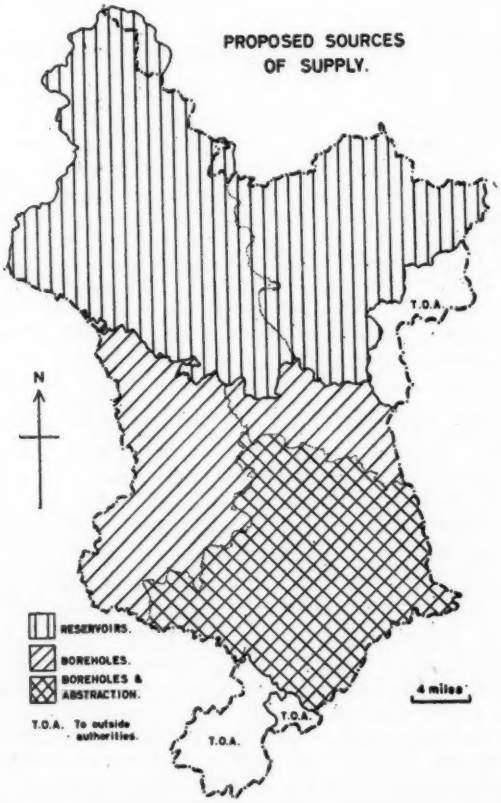


Fig. 4

Derbyshire—Proposed Sources of Supply. (Based on *Water Supply Survey of Derbyshire and South Nottinghamshire*, Ministry of Health, 1950).

Of the large constituent authorities Nottingham is the least dependent drawing only 28·5% of its water from the D.V.W.B. It is also less important in the total regional picture in that it has a large number of adjacent districts within its supply limits and thus has only very small bulk supply commitments, many of which are determined by geographical position and are often reciprocal agreements.

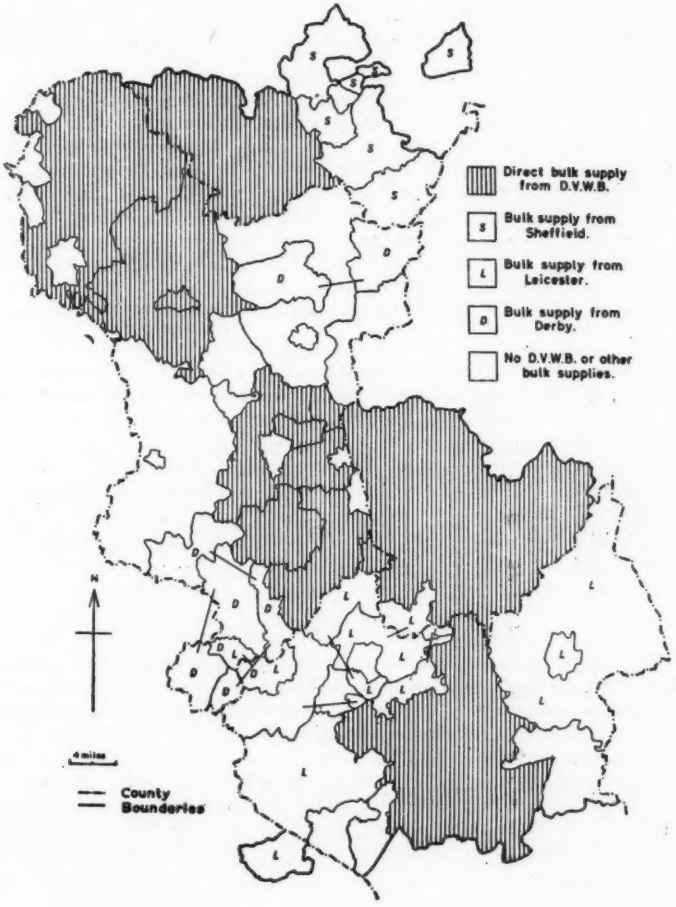


Fig. 5

D.V.W.B. and other Bulk Supplies. (Data obtained from *The Water Engineers Handbook* 1955 and Water Authorities). Boundaries of detailed supply areas shown. Secondary bulk supplies below 50,000 g.p.d. omitted. Parts of S. Yorks., Notts., Leics. and a small portion of Warwicks. are shown on this map as well as the whole of Derbyshire.

Leicester however is dependent upon D.V.W.B. for 82% of its water, the remainder coming from three reservoir schemes to the north of the city, and it also has extensive bulk supply commitments (Fig. 5). The bulk supplies are largely areas where opportunity for local supplies is rather limited, and they have increased quite markedly in recent years due to the expansion of rural water schemes. Whilst it is not possible to distinguish those authorities receiving a secondary bulk supply of purely D.V.W.B. water, it is obvious that if this water were not available then no bulk supplies could be made at all. Thus D.V.W.B. is an important factor influencing water supply as far as Nuneaton and Market Harborough.

Sheffield is dependent upon D.V.W.B. for 34·76% of its water which is a reflection of its position on the flanks of the uplands and of its own well developed reservoir sources. There is however a very high consumption in the city due to industrial consumption which is only 140,000 g.p.d. less than domestic consumption, (13·74 m.g.d. to 13·88 m.g.d.), an uncommonly high figure. Bulk supply commitments are also extensive (Fig. 5) and amount to approximately 8 m.g.d. The water supply problem is acute in Sheffield as it is in Leicester and it was estimates of considerable deficiences in these two areas that led to a reassessment of water policy by the Ministry of Health Inspectors in 1949.

Compared with the other large towns in the area Derby is favourably placed in relation to water supply, for although 79·3% of its water comes from D.V.W.B. (7·9% for Chesterfield, Bolsover and Clowne Water Board, 71·4% for its own supply), the Corporation is able to sell over 2 m.g.d. of its entitlement back to the Board, in addition to its supply to Chesterfield. This is due to its own resources which consist of abstraction tunnels in the alluvium alongside the river Derwent and to the fact that the town did not expand as rapidly or as much as its planners at the end of the 19th century thought it might.

Future Supplies

The future of water supplies in Derbyshire involves a wide regional appreciation, for modern developments have led many areas to outstrip their local resources of water and to look further afield for increased supplies. D.V.W.B. itself is an example of this, and the nature of its constituent authorities and of their bulk supply zones shows why any future water policy for Derbyshire becomes related to the problem of the adjacent areas. These regional inter-relationships have been emphasised in a memorandum prepared by the Ministry of Health Inspectors(1), which considered the whole of the West Riding and the North Midlands.

This report estimated that there would be two major deficiencies in the area by 1970 and that "the only economical solution of the problem appears to depend upon a reallocation and eventual augmentation of the resources of the D.V.W.B." The deficiencies are expected to be 13·7 m.g.d. in the Sheffield area and 2·5 m.g.d. in the Leicester area, the latter

(1) *Water Supply Survey of Derbyshire and South Nottinghamshire*, Ministry of Health, 1950.

figure depending upon the offsetting of Nuneaton's bulk demand and upon the provision of 7·00 m.g.d. from the River Dove Scheme started in 1956.

The present figures of supply to Leicester and Sheffield, approximately 15·00 m.g.d. and 12·5 m.g.d. include the provision of additional water, the sales of water between authorities, and for the fact that the Derbyshire county authorities do not take their full entitlement. In 1964 these sales agreements end and it is also estimated that the county authorities will, by then, be taking their full entitlement. Given no addition to resources the statutory share would result in the quantities shown in Table 4. This would accentuate the deficiencies estimated for Leicester and Sheffield and the case for a reallocation of resources is strengthened.

TABLE 4

DISTRIBUTION AFTER 1964 IF SUPPLY REMAINED THE SAME

	million gallons per day
Derbyshire County Authorities	6·5
Derby C.B.	9·05
Leicester C.B.	12·91
Nottingham C.B.	5·61
Sheffield C.B.	9·05
Losses and wash water	0·13
	43·25

Another factor in favour of reorganisation is stressed by reference to the boundaries of water supply undertakings shown on Figure 5 for the regional area and on Figure 6 for Derbyshire. The areas represented by these boundaries are for detail suppliers, but the type of authority controlling these areas varies from one area to another, as is the case over the rest of the country(1). Most are local authorities, although their water supply limits may not be co-terminus with their boundaries for other local government functions; some are joint boards, often the amalgamation of two or more local government areas, e.g. Chesterfield Bolsover and Clowne Water Board; whilst others are private companies whose boundaries do not necessarily correspond to those of local government areas. South Staffordshire Waterworks Company is the largest private water company in Britain and comes into this area to supply part of Repton R.D.C.

This complex pattern of undertakings, and the varying size and efficiency of the units controlling them, is not considered to be the most economical or the most efficient way of providing water. To some extent these undertakings are a legacy of an earlier period and although changes have occurred, such as the amalgamation of small units into joint boards, the basic pattern has not been radically altered. The creation of larger units for detailed supply, units that would also be responsible for developing their own resources, could lead to a better distribution of potential reserves, a more efficient system of control, and the basis for a possible national water grid. Specialist staff could then be employed,

(1) Gregory, S., "Water supply maps of England and Wales", *Town Planning Review*, Vol. 28, No. 2, July 1957, pp. 145-163.

a practice in which many small units cannot now engage in the interests of economy, despite the need for careful attention to their sources and systems. In addition to this the units would have sufficient financial strength to undertake large scale development as it would be required.

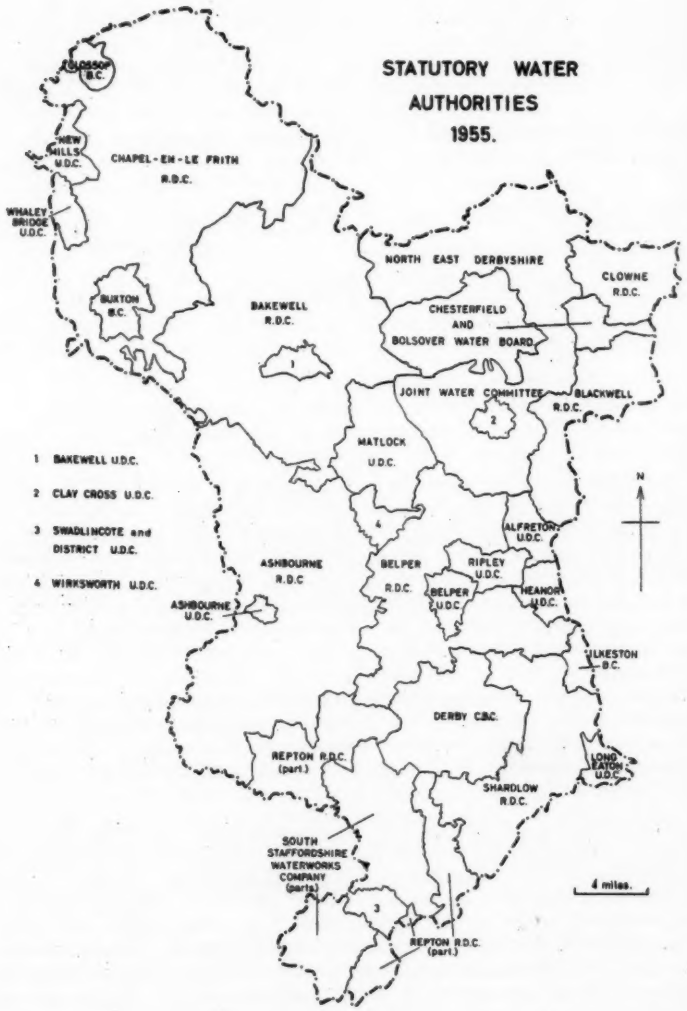


Fig. 6

Statutory Water Authorities in Derbyshire 1955. (Based on *Water Supply Survey of Derbyshire and South Nottinghamshire*, Ministry of Health, 1950).

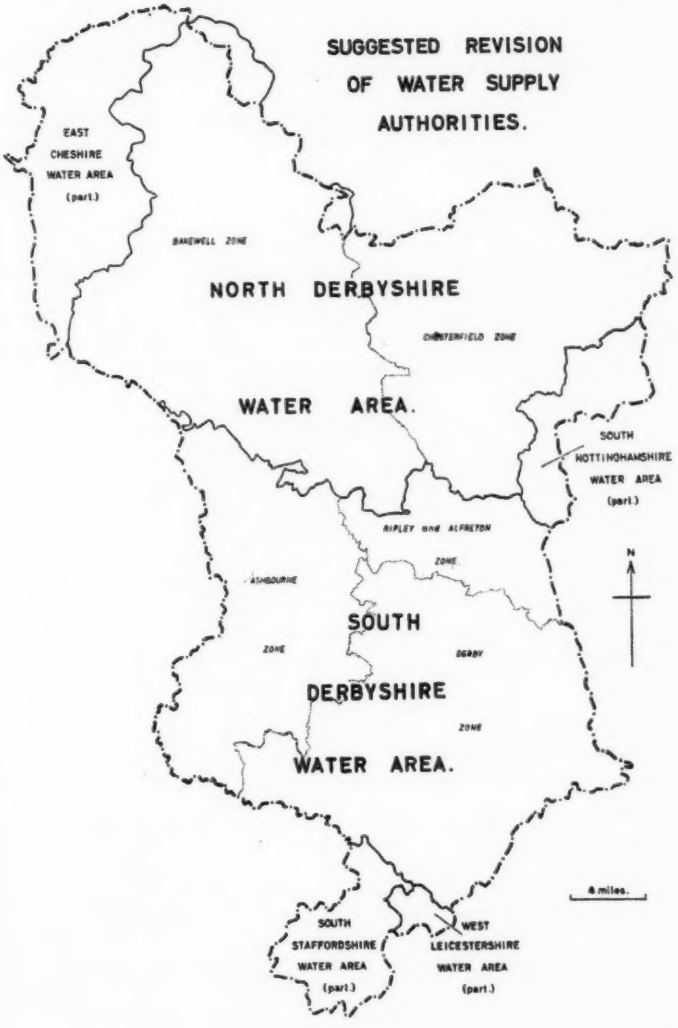


Fig. 7

Suggested Revision of Water Supply Authorities. (Based on *Water Supply Survey of Derbyshire and South Nottinghamshire,* Ministry of Health, 1950.)

As a result of this and other considerations the Ministry of Health Report suggested not only that the authority boundaries should be revised (Fig. 7) and that sources should be changed (Fig. 4) but also that the resources of the D.V.W.B. should be reallocated. They suggested that 12·1 m.g.d. should go to the North Derbyshire Water Area, that 15·1 m.g.d. should go to Leicester and that 21·97 m.g.d. should go to

Sheffield. This would give a deficiency of over 7 m.g.d. which it was expected to obtain from the construction of further works and from the purchase of compensation water. The South Derbyshire Water Area would be recompensed for the loss of its D.V.W.B. supplies by increased abstraction from the Derwent and from Meerbrook Sough, as well as by the continued use of one or two major boreholes, especially the Belper U.D. source near the Derwent. Nottingham would be expected to obtain all her requirements from Bunter sandstone and Trent gravel sources.

This scheme was criticised, especially by the Derbyshire County Council Development Plan, in that only 24% of Derwent Valley water would supply Derbyshire, whilst over 50% would go to the West Riding. However, if rationalisation of water supplies is to occur and more economic and efficient units are to be created, then some reallocation and adjustment in the distribution of Derwent Valley water must take place, so vital a part does it play in the regional water scene.

Conclusion

Whether such reorganisation and reallocation can be applied by the undertakings themselves, with guidance from the Ministry responsible (now the Ministry of Housing and Local Government), or whether it will be applied more or less by force on a national scale remains for the future to decide. The responsible Minister has recently tried to encourage such a reorganisation(1) but at present the pattern of authorities remains very little changed from 1929. However as demand goes on increasing, so changes in organisation, distribution and supply will become even more necessary.

(1) *Regrouping of Water Undertakings*, Ministry of Housing and Local Government Circular No. 52/56, September 1956.

THE EMPLOYMENT STRUCTURE OF NOTTINGHAM, DERBY AND LEICESTER

E. M. RAWSTRON

The Industry Tables of the 1951 Census (H.M.S.O. 1957) provide a large amount of new statistical material that should permit a clearer geographical description of the employment structure within Britain(1) than has hitherto been possible. As far as the patterns of employment can be deemed to represent the patterns of production the census gives a reasonably clear guide to these also.

Unlike the 1931 census the statistics are given for place of work, not for place of enumeration. This is a great improvement for the geographer since it enables him to describe more effectively the industrial patterns of urban areas such as London and south-east Lancashire where journeys to work are often lengthy and where place of enumeration may be some distance from place of work. The use of the census is not, however, without disadvantages and difficulties. Not only does it refer to employment rather than to output but it refers to census areas which in themselves may or may not be significant geographically. If a census area encompasses, for example, a geographically distinct and separate urban unit, then the data will give a useful representation of the employment and industrial structure of a meaningful region defined by the grouping of settlement. If, however,the boundary of the census area bears no relation to the pattern of, for example, settlement or land use, then to the geographer its use in isolation is not great. But even such arbitrary census areas could be used either with the shading method or perhaps preferably with proportional symbols to give a fair representation of the patterns of industry over the country as a whole.

The purpose of the present article is, however, to outline the employment structures of Nottingham, Derby and Leicester, the chief towns of the East Midlands. Since their borough boundaries, used by the census, do not represent the limits of the three towns in the full geographical sense, an attempt was made first to arrive at more realistically defined areas by adding employment data for certain census districts adjacent to the boroughs. While this brought some apparent refinements it likewise caused additional difficulties with regard to Nottingham and Leicester. The borough of Derby is a fairly distinct and separate settlement unit and therefore seemed reasonably acceptable without modification. Data for the other two amended urban units were compiled but, although the information provided is used to qualify some of the findings described below, it was deemed preferable to treat the census data for all three towns without modification, for the addition of adjacent areas does not generally alter the proportions of employment to any significant degree.

(1) The Industry Tables for Scotland were published in 1956.

NUMBERS EMPLOYED IN MAJOR INDUSTRIAL ORDERS AND THE PROPORTIONS THESE REPRESENT IN THE EMPLOYMENT STRUCTURES OF NOTTINGHAM, DERBY AND LEICESTER.

Order in Standard Industrial Classification		*Nottingham*		*Derby*		*Leicester*	
		Number Employed	*Percentage of Total*	*Number Employed*	*Percentage of Total*	*Number Employed*	*Percentage of Total*
II.	Mining and quarrying ..	2,480	1.3	A	<1	A	<1
IV.	Chemicals and allied trades.	4,935	2.9	1,228	1.2	A	<1
V. and VIII.	Metal manufacture and metal goods not elsewhere specified	A	<1	5,178	5.2	3,310	2.0
VI.	Engineering, shipbuilding and electrical goods ..	10,073	5.9	5,017	5.0	21,172	12.3
VII.	Vehicles	10,567	6.0	22,725	22.8	2,671	1.8
X.	Textiles	23,597	13.4	16,061	16.1	31,207	18.6
XII.	Clothing	11,283	6.6	1,888	1.9	21,056	12.6
XIII.	Food, drink and tobacco ..	11,030	6.4	1,720	1.7	3,093	1.8
Miscellaneous manufacturing ..		12,489	7.3	2,973	3.0	13,772	8.2
XVII to XXIV.	Services (C) ..	84,369	49.5	42,701	42.7	69,713	42.0
	Total (B) ..	170,898		99,701		167,107	

(A) The numbers employed in industries with less than one per cent of the total are included in "miscellaneous manufacturing".
(B) The totals include also returns that cannot be classified in any "Order".
(C) See footnote (1) below.

The diagrams and table give details of the employment structures of the three towns. The most striking feature as with most large towns today is the large proportion employed in what may loosely be termed service industries(1). Nottingham leads with 49·5 per cent. and Derby and Leicester are about equal with 42·7 and 42 per cent. respectively. Significantly the proportions engaged in building and contracting'(2) are almost equal. Derby, as might be expected, leads easily in 'transport and communications' but falls well behind in the 'distributive trades' in which Nottingham with its more populous hinterland is somewhat ahead of Leicester. Similarly Nottingham is considerably more important as a centre of 'insurance, banking and finance', 'public administration and defence', 'professional services' and 'miscellaneous services'. The last named includes entertainment, sport, catering and a number of personal services. These findings are little modified if "greater" Nottingham and Leicester are considered.

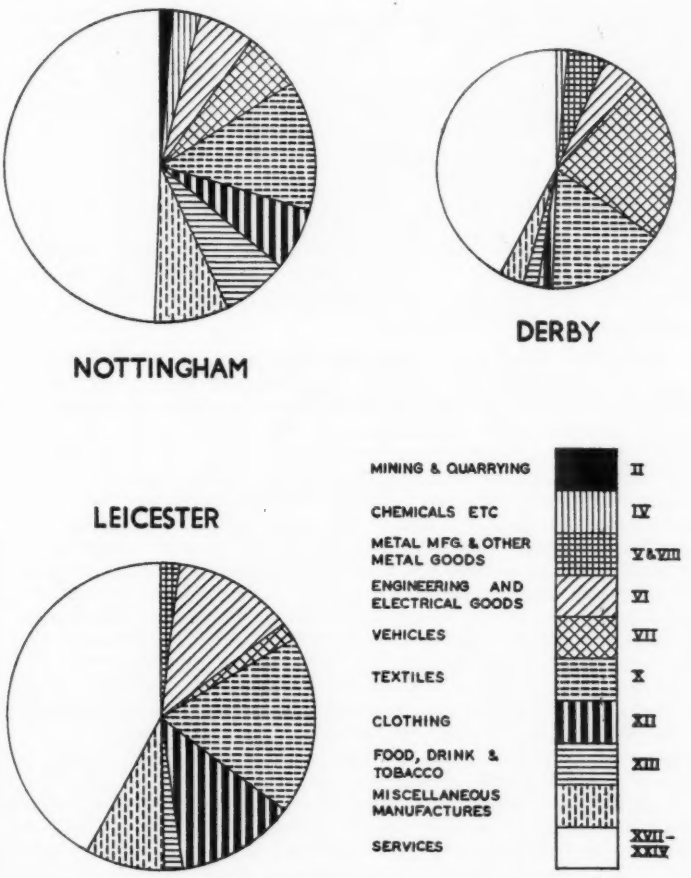
In the manufacturing industries all "Orders"(3) with more than one per cent. of the total employed population are listed in the table and shown in the diagrams. Those with under one per cent. have been added

(1) The so-called service industries have been taken to include building and contracting; gas, electricity and water; transport and communications; distributive trades; insurance, banking and finance; public administration and defence; professional services, and miscellaneous services.

(2) The use of single inverted commas denotes the names of "minimum list headings" within the "Standard Industrial Classification" used in the census.

(3) The term "Order" in the "Standard Industrial Classification" means "major industrial group", e.g. "Chemicals and Allied trades", "Engineering, shipbuilding and electrical goods".

together and with "Orders" 'manufacture of wood and cork', 'paper and printing' and 'other manufacturing industries' have been made into a miscellaneous group of industries of less immediate interest in these towns.



The Employment Structures.

The much smaller proportion engaged in this miscellaneous group in Derby than in the other two towns epitomises its employment structure. Derby is by far the most specialised with nearly 23 per cent. in the vehicles group of industries and 16 per cent. in the textiles group. The biggest item in the former is 'manufacture of aircraft : vehicle parts' and the two large items making up most of the remainder are 'manufacture and repair of wagons' and 'railway locomotive shops'. In textiles three-quarters are employed in 'rayon, nylon, etc., production' and 'rayon, nylon, etc., weaving and silk.' The metal industries, especially notable among these being 'iron foundries', make up 5 per cent. as does a heterogeneous group of engineering industries. The industrial structure

of Derby may thus be summarised as comprising three large concerns, Rolls Royce, British Railways (represented both in the manufacturing and service sectors) and British Celanese. The engineering and metal industries follow these but involve several firms.

In Leicester three industrial orders ('engineering, shipbuilding and electrical goods' 12·3 per cent., 'textiles' 18·6 per cent., and 'clothing' 12·6 per cent.) dominate the employment structure in manufacturing. The engineering and electrical sector is considerably diversified within itself. The largest item here with almost half the total is 'other non-electrical engineering'. 'Textile machinery' is important with a quarter of the total and the remaining quarter is divided evenly among 'machine tools', 'wireless apparatus and gramophones', and 'wireless valves and electric lamps'. Textile manufacturing is dominated by 'hosiery and other knitted goods' employing five-sixths of the total. Similarly footwear production employs three-quarters of those engaged in clothing manufacture. Finally it may be noted that very large concerns do not have so great a share in the employment structure in Leicester as they have in Derby.

The chief feature of employment in Nottingham is diversity of industries. Only textiles (13·4 per cent.) exceed 10 per cent. and four "Orders" in the standard industrial classification have rather over 5 per cent. each. The miscellaneous group, larger in Nottingham than in Leicester or Derby, adds to this diversity. 'Engineering, shipbuilding and electrical goods' with 5·9 per cent. contain two major components, namely 'other non-electrical engineering' and 'textile machinery'. Far fewer are employed in textile machinery manufacture than in Leicester. The engineering figures for Nottingham might however be considered somewhat misleading because a large electrical goods firm which is an important source of employment in the Nottingham district has its site in Beeston and is therefore excluded from the statistics for the borough of Nottingham. Its inclusion along with all other employment in "greater" Nottingham raises the proportion in 'engineering and electrical goods' to about 7 per cent. In 'vehicles' (6 per cent.) the firm Raleigh Products Limited, is dominant. Similarly, as was to be expected, employment in 'food, drink and tobacco' is three-quarters in tobacco. The exclusion of Players would bring the figure under this heading into line with the proportions in the other two towns. The number in chemicals may seem less than expected. This is because one of the two large factories of Boots Pure Drug Company is situated in Beeston on the boundary with Nottingham. Its inclusion in Nottingham would raise employment in chemicals from 2·9 to 4·1 per cent. Clothing is a diverse group with two-fifths concerned in 'dressmaking' and about a third in the production of 'overalls, shirts and underwear'. In its traditional 'textiles' Nottingham has nearly 8,000 fewer workers than Leicester (23,000 against 31,000). Hosiery is far less significant than in Leicester and lace is now a small industry employing only about half of the total of either Players or Raleigh. Perhaps the most striking feature of textiles in Nottingham is the large number (6,000) employed by textile finishing firms, a far larger number than in Leicester. Nottingham is thus characterised by a wide range of industries but among these are to be found a number of large concerns each employing several thousand people. In this respect it would seem to stand between Derby and Leicester.

EAST MIDLANDS RECORD

THE NEW TOURIST MAP OF THE PEAK DISTRICT.

To all in the East Midlands and beyond who cherish the hill country of Derbyshire and the adjacent counties, the appearance of the new One-Inch Tourist Map of the Peak District, published by the Ordnance Survey, is a welcome event. The first tourist edition covering this area was published in 1924 and served a useful purpose for many years, although a tourist map of the Peak on the half-inch scale was issued in 1936. For a long time however, particularly since 1949 when the Peak District was established as the first of our national parks, there has been a real need for another map. The new one, besides being reasonably up-to-date in its detail, is also much improved as regards style and appearance. Those responsible for its design have aimed at, and have undoubtedly succeeded in providing a clear and attractive map of practical use to the general public including hikers and holiday-makers. For teachers and students on field excursions it is invaluable.

The limits of the sheet, with Manchester and Sheffield on the west and east respectively, The Potteries in the extreme south-west corner and Belper in the south-east, enable the whole of the Peak Park territory to be shown with the exception of the northern extremity just beyond Holme Moss. The map is contoured at intervals of 100 ft. and is layer-coloured, while over the highest parts the relief is further emphasised by light hill-shading. The omission of the intervening 50 ft. contours, while reducing detail, certainly makes for clarity as far as general land-form interpretation is concerned. For upland country such as the Peak the system of layer colouring used here is generally satisfactory. All land below 700 ft. is shown in light green, though a solid tint instead of the fine hatching would have been preferable; for the surface above 700 ft. five tints of light brown are used, changing at intervals of 200 ft. up to 1,700 ft. It is not clear why the change from green to brown should be made at 700 ft., for there is no general break of slope at this altitude while there is something to be said for keeping to the conventional distinction between upland and lowland at 600 ft. Since the darkest tint is introduced on the high ground, at 1,700 ft., the two areas exceeding 2,000 ft. (Kinderscout and Bleaklow plateaus) which contain the true High Peak, do not appear quite as prominently as they should. In the absence of further tints, the areas reaching to just over 2,000 ft. (Kinderscout and Bleaklow plateaus) are prevented by the hill shading and the prominence of the contours from appearing too flat. Over the whole map the avoidance of dark tints and the delicacy of the hill-shading combine to give an unusually clear impression of the relief. The rest of the topographic details, like the printing of names, are in the style of the Seventh Edition One-Inch sheets. The National Park boundary is shown appropriately in green without being over-conspicuous.

It should be noted that the Roman fort at Brough in the Hope Valley is given its currently accepted name of *Navio*, while the fort near Glossop, shown on many Ordnance Survey maps by its non-Roman and somewhat fictitious name of Melandra Castle, is simply termed a Roman fort. On the map of Roman Britain (Third Edition) however this site is named *Ardotalia*.—K.C.E.

International Geographical Union Newsletter.

In connection with the note in our last issue (No. 7, June 1957, p. 53) on the International Geographical Union Newsletter, we are able to add that geographers and institutions in member countries may obtain the Newsletter from the National Committee which in the case of Great Britain is appointed by the Royal Society. The address of the British National Committee for Geography is c/o The Royal Society, Burlington House, Piccadilly, London, W.1.

Local Excursion Notes.

The Geography Advisory Committee of the Institute of Education (University of Nottingham) consisting of the lecturers in Geography in the constituent Training Colleges has recently prepared a series of notes on field excursions. Each excursion covers an area in the neighbourhood of one of the Colleges and has been selected to show the salient features, both physical and cultural, of the local landscape. Though designed for training college students, these excursions which are planned for a day or a half-day in the field could readily be adapted to the needs of advanced pupils in grammar schools. The areas dealt with are as follows: North Nottinghamshire (Retford, Creswell and The Dukeries); the Matlock area of Derbyshire; Charnwood Forest, the Keuper lowland and the Soar floodplain; the Lincoln cuesta and fenlands; the upper Witham valley south of Grantham; the Trent valley (Melbourne–Repton); the Trent valley (east of Nottingham). Copies of the notes, including sketch-maps, may be obtained at a nominal charge from The Director, Nottingham University Institute of Education, Derby Road, Nottingham.

HIGHER DEGREE THESIS AND FIRST DEGREE DISSERTATIONS

Prepared in the Department of Geography.

In the University, Geography may be read as a subject in the Faculty of Arts, under the Board of Studies in Law and Social Science (Faculty of Arts) and in the Faculty of Pure Science. Since the award of the Charter to the University in 1948 all students taking an Honours degree in Geography have been required to submit a dissertation as part of their final examination. Only those dissertations and higher degree theses relating to East Midland subjects are listed below. *Bona fide* students or research workers may be permitted to consult them on application to the Department.

1957

M.Sc.

The Industrial Structure of the Leicestershire and South Derbyshire Coalfield. A Geographical Analysis. W. D. Holmes.

DISSERTATIONS

Barton-upon-Humber, Lincolnshire. A geographical study. P. E. Bryan.

The development of settlement in the lower Derbyshire Wye valley. P. Carrington.

The historical geography of Wirksworth. G. C. Pearson.

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